1-1-2003

A three dimensional map as a navigation mechanism for web sites

Oscar J. Salazar
Iowa State University

A three dimensional map as a navigation mechanism for web sites

by

Oscar J. Salazar

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
MASTER OF FINE ARTS

Major: Graphic Design

Program of Study Committee:
Sunghyun Ryoo Kang, Major Professor
Alan C. Mickelson
Mikesch Muecke

Iowa State University

Ames, Iowa

2003

Graduate College

Iowa State University

This is to certify that the master's thesis of

Oscar J. Salazar

has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This study examines map design concepts and principles as they apply to effectively navigate an information space. Under the assumptions that one way of facilitating navigation in any man-made environment is to provide a visual representation of its organizing principles. And that the most effective forms of visualization are three-dimensional models, this study proposes that providing a three dimensional representation of the underlying structure of a web site results in increased navigation performance.

The literature review addresses the cognitive, functional, visual and factors that determine the effectiveness of navigation systems along with a study of the graphic variables and principles of good web navigation design, providing the criteria to develop a three-dimensional web site-map prototype for a randomly chosen web site.

The interdisciplinary approach used for this research facilitated the discovery of an alternative solution to common problems of web navigation. A three-dimensional map is a real alternative to improving navigation on web sites because it takes advantage of human common experience in the three-dimensional world and perception abilities to make users rely on intuition rather than recall when navigating an information space.

CHAPTER 1

INTRODUCTION

One of the oldest and most effective navigation devices ever created is the map. For centuries, humans in every culture have mapped their environment in order to facilitate its understanding. Maps are a kind of visual code whose goal is to aid people in understanding the world around them. The use of maps is so extensive that it is safe to say that most known environments have been mapped to some degree.

In today's newest environment, the web, site-maps are a common approach to facilitating navigation. However, studies have shown that many site maps are overly confusing and fail to convey all the information users need to effectively navigate an information space (Nielsen, *Site Map Usability*).

Wayfinding research suggests that one way of facilitating navigation in any man-made environment is to provide some kind of visual representation of its organizing principles (Passini). Research also argues that the most effective forms of visualization are three-dimensional models[1](Arthur and Passini). Based on these findings, this study proposes that providing a three dimensional representation of the underlying structure of a web site may result in increased navigation performance.

The goal of this study is to develop a three-dimensional web site-map prototype to increase navigation performance. The study examines map design concepts and principles as they

---

[1] "For most of us, under most circumstances, the only "good" map is a three dimensional, colored model which reduces the complexities of the real world to scale that allows us to understand the environment we are in, where our destination lies, and how best we may get there" (Arthur and Passini, 187).

apply to facilitating navigation. In addition, the study analyzes the visual principles and variables that contribute to the success of map design.

The literature review includes an overview of cognitive factors that determine the effectiveness of navigation systems; a study of the function and visual implications of maps for navigation, and finally, an analysis of the graphic variables and principles of good web navigation design.

The literature review aims to give answers to the following research questions:

What is navigation?

What are the functional and visual implications of navigation maps?

What kind of maps are best for wayfinding?

What graphic elements are in wayfinding maps?

What is web navigation?

What are the performance criteria of web navigation systems?

What are the visual implications of designing web navigation maps?

CHAPTER 2

LITERATURE REVIEW

Different types of visual aids are used in the planning stages of complex web sites. Their purpose is to map out the contents of the site and facilitate the analysis and comprehension of the relationships within. These visual aids, however, are disregarded as navigation devices that may enhance the experience of navigating the site. In order to draw attention to the potential of visualizations as navigation tools, it is important to understand the role of visualization in what concerns the process of navigating an environment. Three main factors determine this role: cognitive, functional and visual factors.

A. Navigation

1. Cognitive Factors

Navigation is a critical issue in the design of any type of environment. Researchers have acknowledged two main implications for the term navigation: wayfinding and travel. The later pertains to the actual movement of a user within an environment. While wayfinding is the cognitive part of navigation and deals with the tactical and strategical parts that guide the action of travel (Darken & Peterson 494).

Wayfinding is a dynamic communication process between individuals and environments. It comprises three specific parts. First, is a perception and processing of environmental information called cognitive mapping, which is the process of extracting information from an environment and constructing a mental model or cognitive map of this environment. Second, is a decision-making process in which knowledge of the environment and experience are combined to develop a plan of action or strategy to reach a desired destination. The third part is a decision execution process in which the individual puts into practice the plan through physical or behavioral actions. (Passini 1984) A good navigation system must provide support mechanisms to assist individuals in each of these phases.

2. Function and Visual Implications of Navigation Maps

Wayfinding systems are composite signage mechanisms provided by most large man-made environments giving access to the public. According to their content, wayfinding research describes three categories of signs. Orientation signs, Identification signs, Directional signs, (Figure 1). Maps give users more than one type of information and fall within the category of orientation signs (Arthur & Passini 30).

The main functions of a map for navigation are to give the user an overview of the environment and to work out a specific route to a destination. These two purposes are different in terms of navigation because there are users whose navigation abilities rely upon a sequence of steps that eventually will take them to the desired destination. Other users rely more on an overall understanding of the setting and will use this understanding to develop various alternative routes to the same destination. Therefore, in order to fulfill these requirements, maps should be able to give the user both, a good idea of the environment at a single glance and to provide detailed information as to how to follow a given route (Passini 149).

Maps are selective abstractions of the reality. In a map, selected characteristics of the environment are depicted and symbolized using visual elements such as symbols, color, typography, and many others visual elements organized according to determined principles.

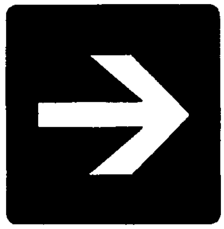
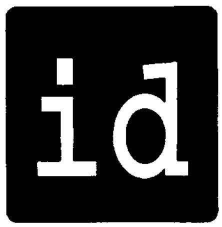
Information type	Description	Examples	
Orientation and general informatiom about the setting. (This is decision-making information.)	• Information that gives users an overview of what "shape" the building has (E, H, T, L, etc.), where they are, and where the destination lies, as well as other relevant information about the general setting.	• Maps, floor plans, exploded views, and models, all with you-are-here arrows on them, and clearly identifying corridors and destination zones. • Building directories. • General dos and don'ts that affect behavior in the building, including safety information.	
Directional information to destinations. (This is decision-executing information.)	• Information that guides people along a designated or pre-selected route to a destination.	• Signs with arrows or plain-language descriptions involving the use of building features or landmarks. • Floor directories in elevator lobbies. • Colored lines on walls or ceilings leading to destination zones.	
Identification of destinations. (This is decision-executing information.)	• Information provided at the destination.	• Signs with names or pictographs at entrances to destinations. • Sometimes safety colors will help to identify equipment. • Signs identifying local hazards.	

Figure 1. Sign categories of wayfinding systems, Arthur & Passini (1992)

Research on map visualization suggests that what goes onto a map are differences.

The visual elements of a map represent the differences between the features of the environment (Bateson). Hence for a map to be visually clear, it needs to show a high degree of contrast between its components. The principle of contrast is perhaps the most important principle for the design of maps because it helps users to discriminate among the various elements. The visual language of a map is made out of a set of variables that facilitate differentiation among elements. These variables, point, line, area, and typography, are used by map designers to represent features of the environment. Their attributes, texture, color orientation shape, are manipulated to facilitate discrimination among them. (Figure 2).

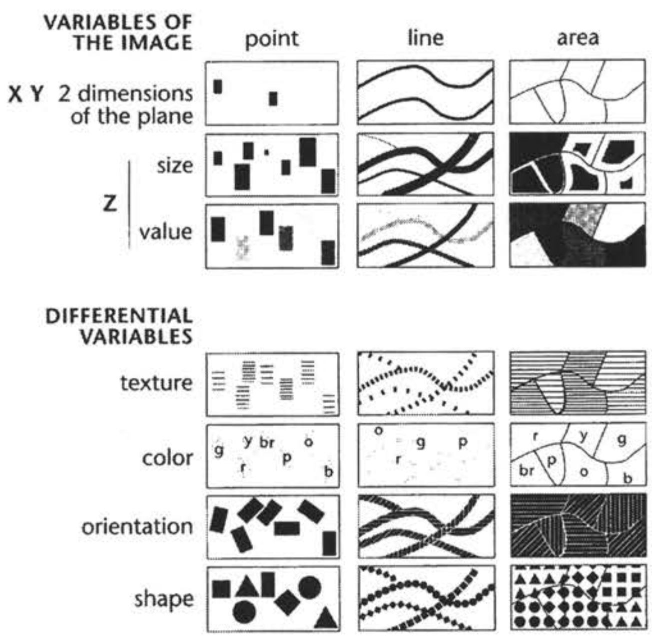


Figure 2. Graphic variables, MacEachren (1995)

As noted earlier, discrimination or the ability of vision to recognize a difference is a key factor in good map design. Studies have shown that human vision has certain limitation discriminating features in maps. For instance, in order to discriminate patterns, they must be coarser than 40 lines or dots per inch; any smaller than that causes the pattern to be perceived as a color value or gray tone (MacEachren 125) (Figure 3).

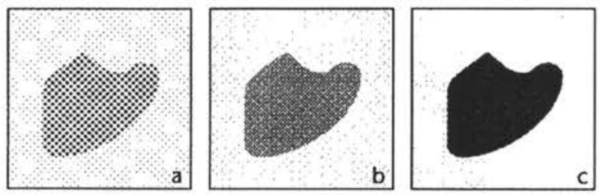


Figure 3. Pattern discrimination. Map areas with 35 lines/inch dot fills (a), 65 lines/inch dot fills (b), 133 lines/inch dot fills, MacEachren (1995)

Another factor affecting discrimination is color. About 8% of men are congenitally red-green color deficient. Our eyes have no blue cones in the peripheral area reducing our ability to detect blue symbols over other hues (MacEachren 126). Despite these limitations, color hue is the easiest feature to discriminate on maps. Studies have shown that symbols that differ in color are easier to discriminate than those that differ in size and shape because color is a dominant feature.

Appropriate color combinations facilitates discrimination especially of point symbols and typography. The results of a study by Borggrafe indicates that certain foreground/background color combinations are better to produce the necessary contrast to facilitate legibility of type (Figure 4), color contrast and point symbols on maps may also conform to this results.

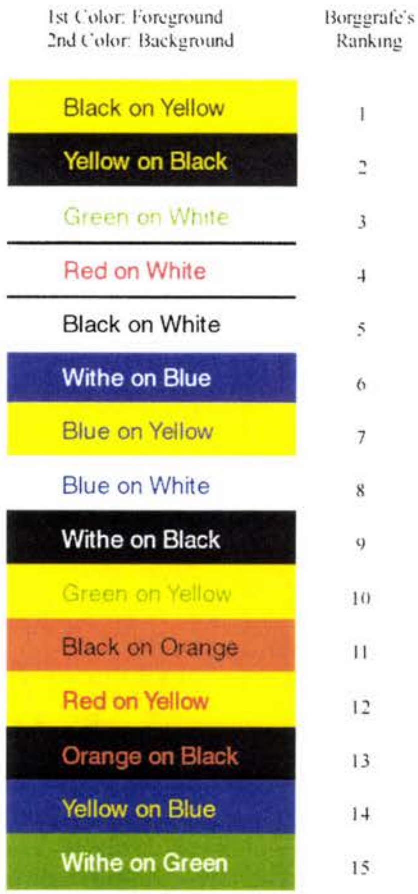


Figure 4. Color contrast to facilitate legibility of type

Studies of point symbols and text discrimination are limited. In terms of size, however, evidence suggests that in a flat white background, point symbol size differences are easier to discriminate when they are between 34%-23%. Smaller differences are consistently difficult to differentiate. Besides size, point symbols have other features that may facilitate discrimination. Point symbols may be pictoric, associative, or geometric (MacEachren 258) (Figure 5). It is suggested that while abstract symbols are easy to locate within a complex display, they often require an initial extra effort to be understood.

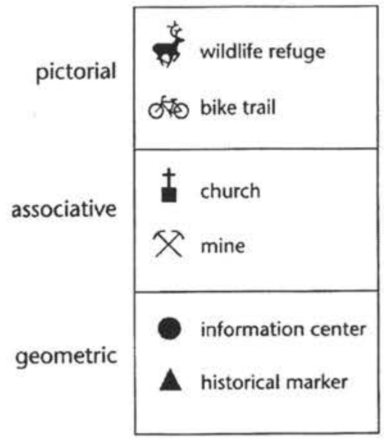


Figure 5. Examples of pictorial, associative and geometric point symbols, MacEachren (1995)

Type discrimination is consistent when type sizes differ by more than 2 point size in height of capital letter; also certain combinations of type attributes are better than others at facilitating discrimination, for instance, type size and boldness combination is easier to discriminate than type size and case combination. In the following figure 75% of readers were able to identify type differences on the right side map, while very few readers did so on the left side map (MacEachren) (Figure 6).

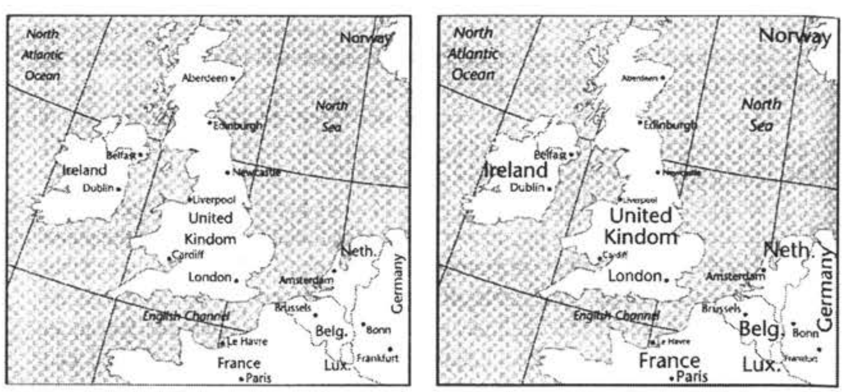


Figure 6. Type differences discrimination experiment, MacEachren (1995)

Other variables in maps are different projections. Plan, axonometric, and perspective projections or a combination of two are the most common. Depending on the purpose of the map, some projections favor certain features. Plan views for instance facilitate the visualization of paths and the relations between areas of the environment. (Figure 7).

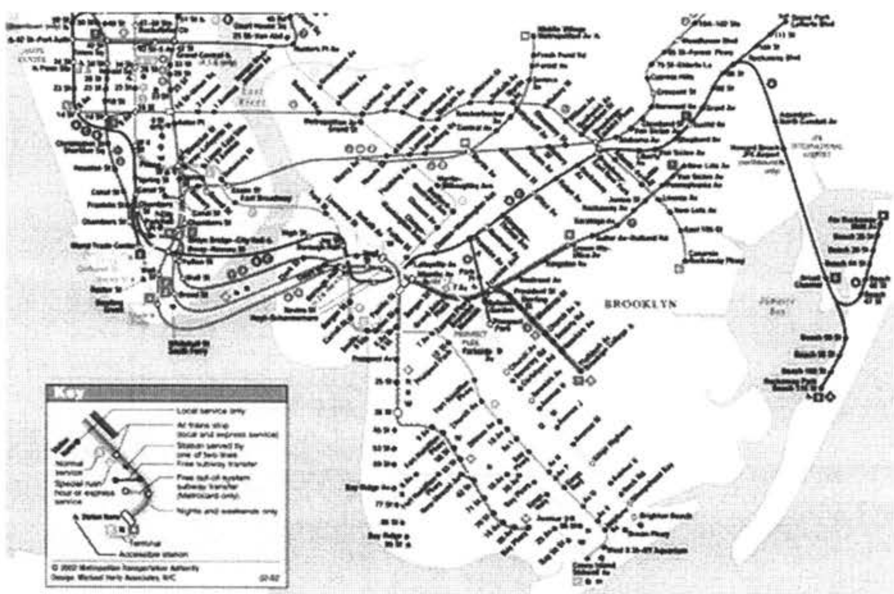


Figure 7. Manhattan subway system plan, (08/10/02)

Axonometric views do not contain metric distortions, so all the elements, foreground and background, are seen. Axonometric views are well suited to emphasize important landmarks; however, for certain environments it is necessary to make adjustments in order not to lose any information that may be hidden (Figure 8).

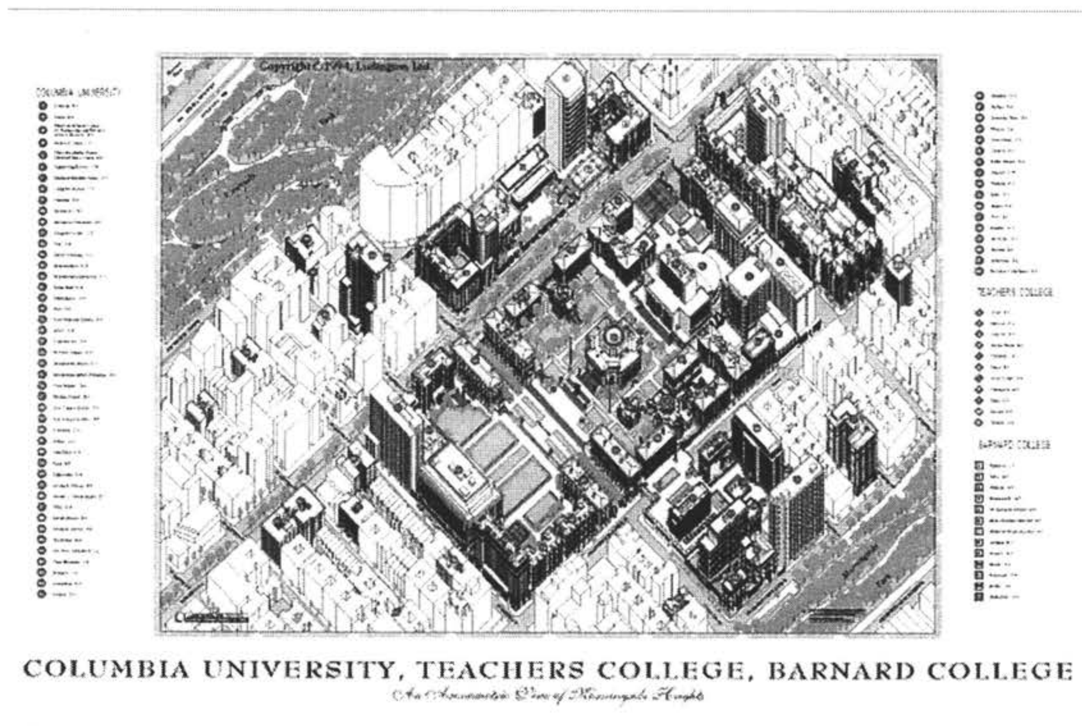


Figure 8. Axonometric view, (01/24/03)

In contrast, perspective views introduce distortions and some far away elements may be lost. This kind of projection is not recommended for navigation maps because it is restricted to a single viewpoint. However, it is a proven fact that people can understand maps drawn in perspective view better than maps drawn in plan view as long as the perspective drawing minimizes its complexity (O'Neill 225-231).

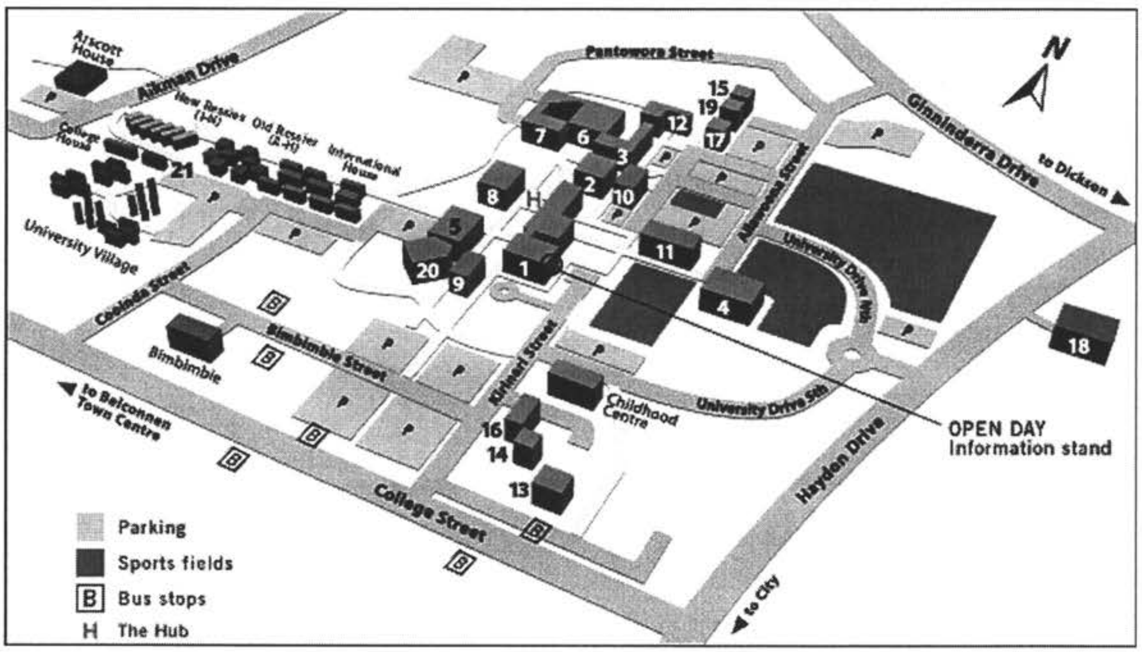


Figure 9. Perspective view, (07/08/02)

There are other forms of representation used in maps, fantasy and schematic maps, although they do not bear resemblance to the characteristics of the physical environment, fantasy and schematic maps are commonly used to emphasize a particular feature. To show existing or pretended qualities of the setting. Figure 10, for instance points out the controlled airspace area by emphasizing the radar coverage. Figure 11, instead emphasizes the modularity of the terminal using geometric shapes.

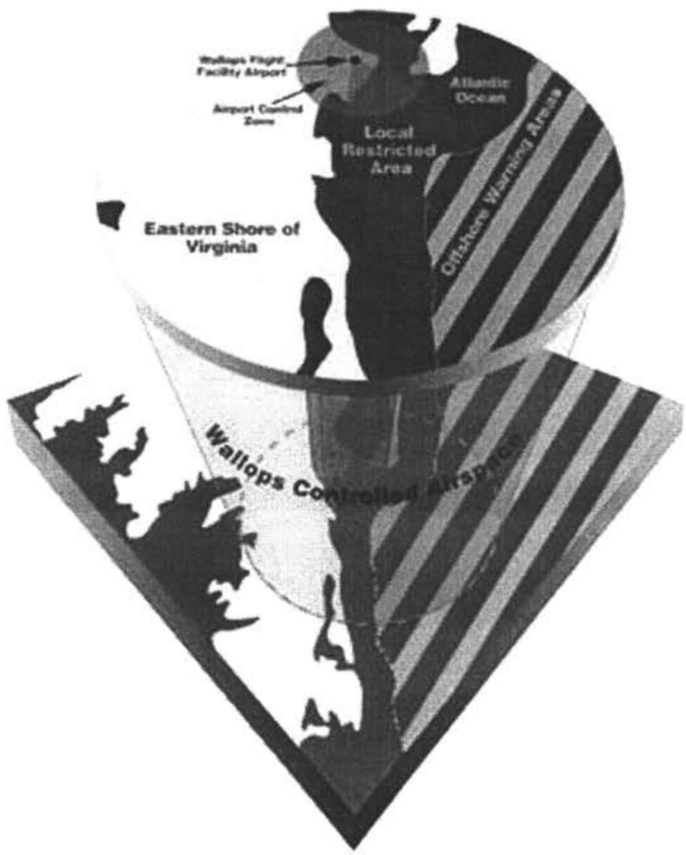


Figure 10. Controlled airspace map, (06/06/03)

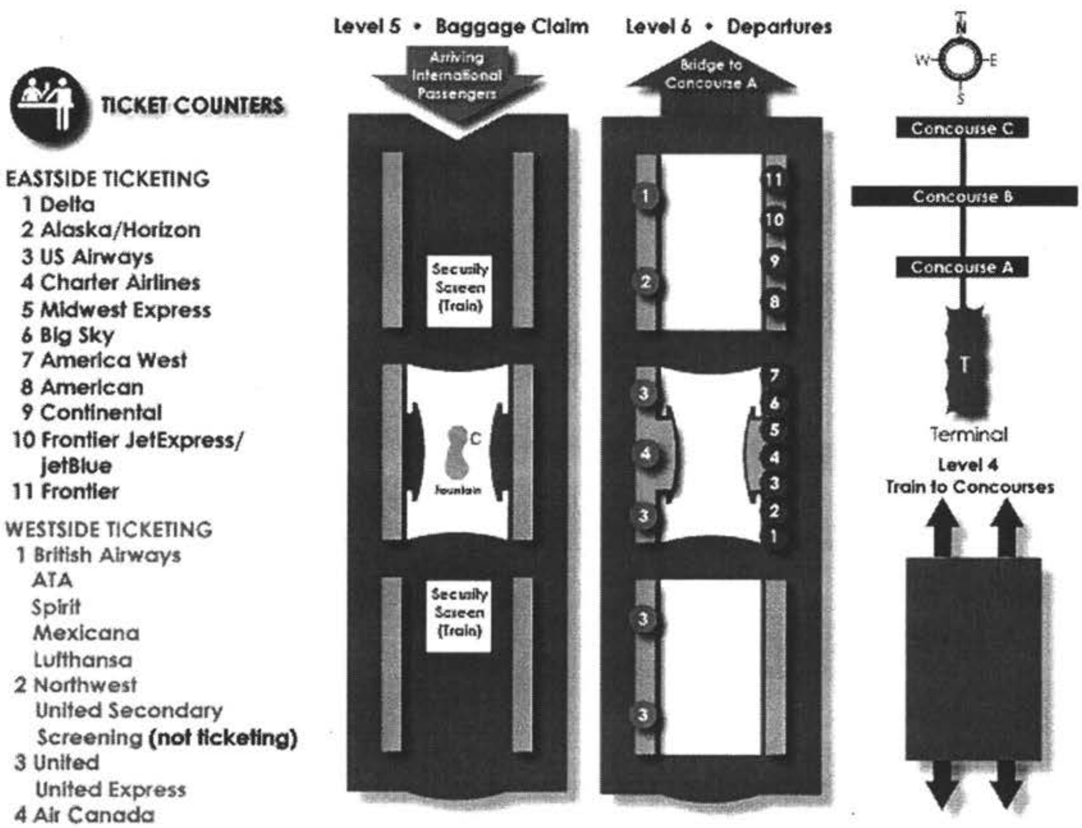


Figure 11. Denver International Airport - Jeppesen Terminal schematic wayfinding map, (02/28/03)

In addition to maps representing physical settings such as cities, buildings, and spaces, there are other forms of maps depicting less conventional characteristics of environments or types of information. The sky, Genetic information, Chemical compounds, even information networks have been mapped to facilitate understanding (Figures12, 13, 14, 15).

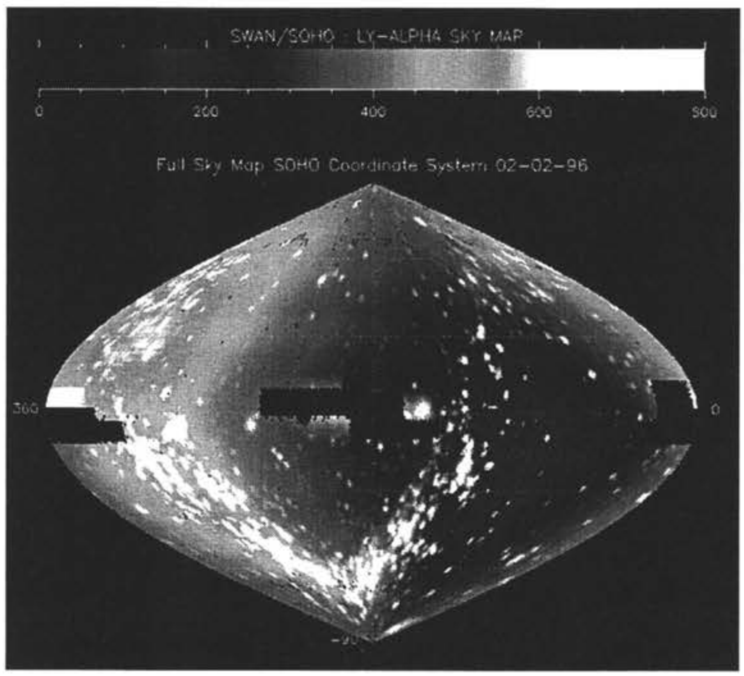


Figure 12. Skymap, (06/11/03)

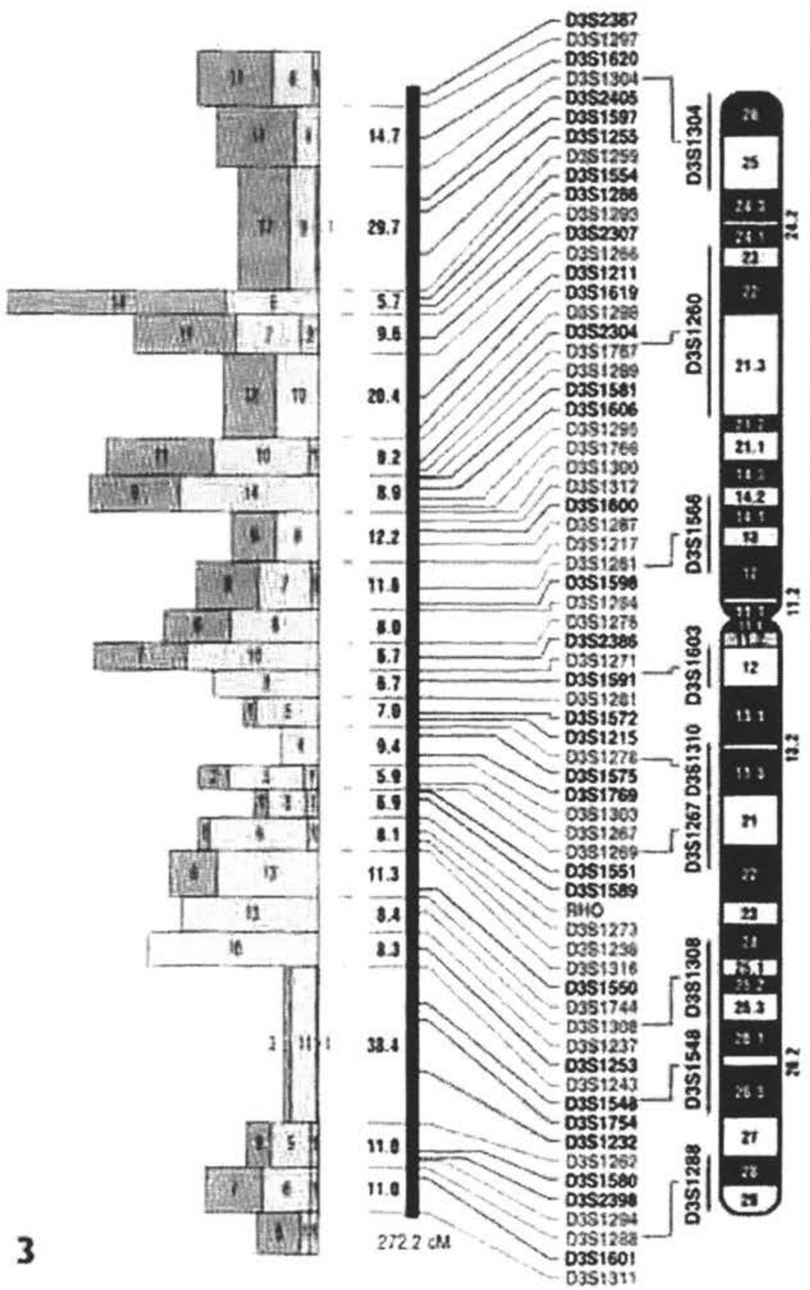


Figure 13. Genome map

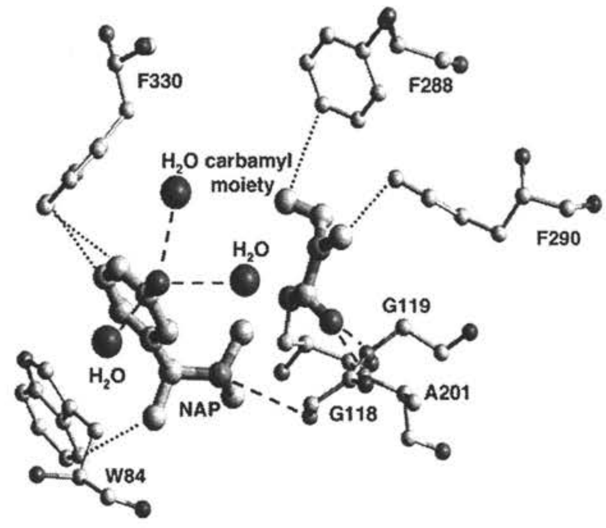


Figure 14. Chemical Compound http://nslsweb.nsls.bnl.gov/nsls/sci&tech/science/2002/images/09-Sussman-figure2.jpg

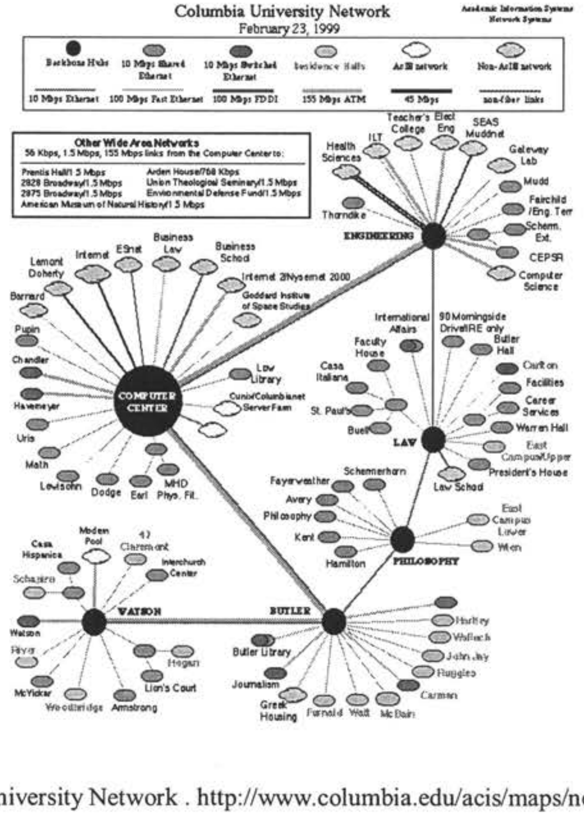


Figure 15. Columbia University Network . http://www.columbia.edu/acis/maps/network.gif

B. Web Navigation

1. Cognitive Aspects

An important objective of interface design is to facilitate the formation of a mental model. As Don Norman explains it, the primary goal of interface design is to create and support an appropriate mental model of the operations and organization of a system. This mental model allows the user to predict the behavior of the system without having to memorize many abstract and arbitrary rules. (Norman 1988). The graphic user interface directs, and focuses the user experience and makes the organizational structure of the system visible and accessible to the user.

Forsythe and Boechler suggests that there are four major reasons why 58% of users make navigational errors while searching for information on a website.

a. Disorientation, which arises from unfamiliarity with the structure or conceptual organization of the site.
b. Digression problem, which occurs when users pursue digressive paths within websites and lose their place or forget to return to their original document.
c. "Art museum" problem, which refers to the lack of memory for the navigational details of a significant part of the site because the viewer is overwhelmed by the sheer amount of information.
d. The structure itself, which generates fewer navigational mistakes when the hierarchical structure of the site is broader rather than deeper.

There are several ways in which these difficulties may be addressed. Organizing the site according to the typical user mental model of how a site should be organized reduces the problem of disorientation. The use of navigational aids such as color-coding, consistent logos and banners also reduces disorientation. Research has found that ideally all information should be placed within three hierarchical levels from the initial homepage of the site (Rosenfeld 36-39). This helps in reducing the cognitive overload in complex hierarchies. Site maps present the structure of a site in a more cognitively manageable way by showing a site's main structure and the relationships among the components of such structure.

2. Functional Aspects

Designers have unlimited alternatives to support navigation difficulties. However, effective navigation does not come from the amount of devices implemented in a specific site. Rather, the success in navigation design highly depends on a set of qualities that have been consistently proven to enhance the user experience. These qualities were listed in Flemming's Web Navigation: designing the User Experience.

a. A successful navigation system should be one that is easily learned by users. If finding information on a site requires an excessive effort by users, they would simply abandon the task and try somewhere else. Information should be readily available.

b. Successful navigation systems should remain consistent through the entire site. Users expect navigational aids to be consistently placed. It has been found that the ability to predict where the navigation is located represents a time saving device in making choices.

c. Navigation systems must provide feedback. Users are conditioned to expect responses from their actions. So responsive mechanisms such as rollover effects greatly enhance the user experience. Also as annotated earlier, users require information about their location within the environment. This is probably the most important feedback that can be provided by the navigation system.

d. Navigation systems should appear in context. In order to complete a task, users may need certain information at some point. This information must be available exactly where it is needed without the user having to go back or search in another page for it. Context information is particularly important in web-based information spaces because users usually do not come from a predictable place. They may come into the site from a link on another site and they need to easily understand where they have landed.

e. Navigation systems should offer alternatives. There are many kinds of users out there each with its own preferences as to what kind of information they would rely on for navigation. There are users who prefer using global navigation mechanisms such as site maps and site indexes. While others, especially those familiar with a particular site, would be more inclined to local mechanisms such as menus. Among users are also some who would be more inclined to information that is text based, while others would pay more attention to pictorial representations.

f. Navigation systems should require minimal action and time. Nowadays the web is used for many business purposes that represent cost in terms of time expenditures. Therefore providing easy to access information without effort is a key aspect of navigation design. There are many sites that force users to travel through several layers of no content pages before they are presented with what they are trying to find. Navigation should provide shortcuts to avoid these scenarios.

g. Navigation systems should be visually clear. Visual hierarchies are important in navigation design. As annotated earlier, users expect the navigation devices to be easily recognizable. The current state of the web has made impossible to define conventions for every situation when navigating information spaces; however, the existing ones have shown to increase user performance. Clement Mok and Jakob Nielsen have advocated the use of such conventions as a way enhance everybody's experience with the web.

Navigation systems should be appropriate for the site purposes and the user goals. The design of such systems is a complex area that requires intensive planning and forethought. An extremely good solution for a site may turn to a complete fiasco for another site. Therefore it is important to begin by understanding the specific goals of the site and what the users are supposed to accomplish.

3. Visual Aspects

Jakob Nielsen states that "Graphic design is the first and last part of a user interface observed by the user" (*Seductive User Interfaces* 1). The user interface comprises the interaction images, concepts, and methods necessary to communicate function and meaning through a computer screen.

The visual structure of a graphic user interface consists of standard objects such as buttons, icons, text fields, windows, and screen menus. These interface objects convey particular messages to the user about the functional possibilities and capabilities of the system or document in use. (P.Lynch, *Design Fundamentals* 24). In other words, they are the navigation support mechanisms that allow users to interact with the system. There are several factors influencing the design of these interface objects: layout, typography, symbols, color, and 3D models.

a. The layout

The overall graphic balance and organization of the page is crucial to engaging users into the content of an interactive document. The layout conventions for print documents have evolved over hundreds of years for concrete and practical reasons, and they offer many advantages to enhance communication. A dull only plain text without visual cues to the structure of its content repels users, while a well balanced visually structured page helps users make predictions as to where important information may be located. This ability of making predictions about structures of information is fundamental to the success of a navigation support system.

The layout of the graphic user interface seeks a balance between the practical need of information management and the esthetics of presenting this information to the user. This layout is built up through the systematic use of the interface elements, which may be laid out according to a grid similar in structure and function to that used for the design of printed documents.

b. Typography

The main purpose typography in a navigation device should be legibility; however, because typography still depends on variable factors such as an out of date browser or a user set of font preferences, typographic specifications may vary from one screen to another. Evidence suggests that the most commonly used fonts tend to be equally legible at the 10-, 12-, and 14-point size. A study comparing commonly used typefaces at a resolution of 1024 x 768 revealed no difference in effective reading between font types (Bernard, Lida, Riley, Hackler, & Janzen, 2002) (Figure 16).

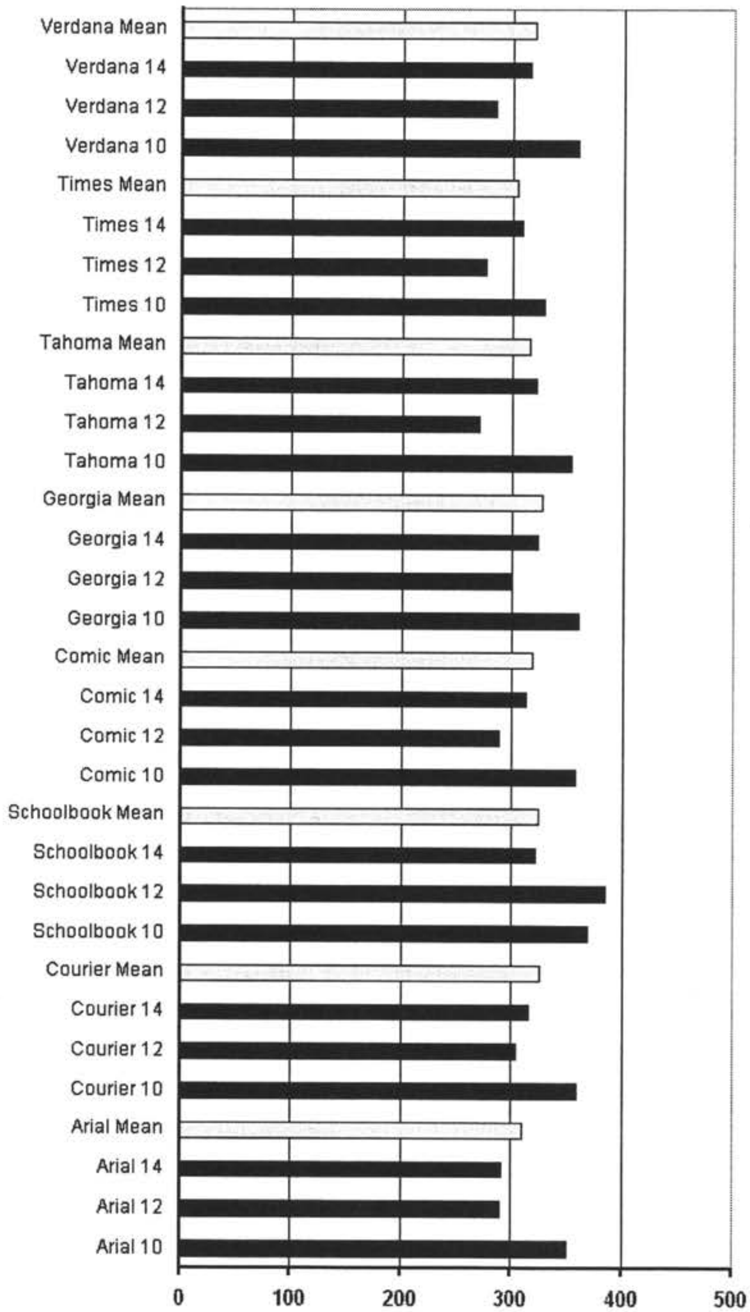


Figure 16. Reading time in seconds (longer bars indicated longer reading times) types (Bernard et al, 2002)

Although most typefaces have been adapted for use in computers, they are still not optimal faces for screen displays. In general, typefaces developed for low resolution media share certain characteristics, such as large x heights and simple character shapes. Because typography depends on variable factors, typographic specifications vary from one screen to another. However, as technology evolves, designers have more control over the way typography actually displays in the screen. In what concerns legibility, appropriate typography requires an adequate visual relationship among letterforms and between text blocks headlines and the surrounding white space. Line length is another important issue. At a normal reading distance, the eye's span of acute is only about three inches wide, therefore wider lines may become uncomfortable because force users to slightly rotate their heads to track over long lines (P.Lynch & Horton 85). The principles of good typographic design: hierarchy, contrast, spacing, patterns of organization etc., can be applied directly from the world of print design.

c. Symbols Icons

User interfaces should allow users to recognize and understand the meaning and function of the different elements. The use of images and words combined together allow users to rely on recognition, not recall, to understand those meanings. Otto Neurath, who was concerned with symbol-word relationship, saw the importance of combining symbols and simple keywords as a means to communicate relatively complex information. "The aim is to present some worthwhile information, show up some relationship or development in a striking manner, to arouse interest, direct attention, and present a visual argument which stimulates the on looker to active participation"

Symbols-icons are powerful elements capable of conveying complex information. However, the lack of standards for the design of such interface elements has favored the proliferation of many symbol-word combinations. This has forced users to learn new meanings every time they visit a new site, making the experience of visiting new sites somewhat demanding. (Boechler 27).

d. Color

According to the Institute for Color Research, all human beings make a subconscious judgement about a person, environment, or item within 90 seconds of initial viewing, and that between 62% and 90% of that assessment is based on color alone. This fact gives color a major role in interface design.

Colors convey specific messages but its interpretation is influenced by many variables such as gender, cultural background, and personal preferences.

Color is a very useful tool to create contrast. In computer simulations, the RGB model can be exploited to support and emphasize the message.

e. 3D models

As well as in the physical world, 3D representations appear to be more efficient at presenting complex structures of information. Due to our common experience in the physical world 3D representations are easier to grasp by our intuitive understanding of space (Kahn, Lenk, Kaczmarek 223). A study by Biederman indicates that 3D elements used in interfaces are easier to identify and remember. Finally by effectively using depth cues, 3D representations are able to accommodate more information than a 2D representation without becoming excessively wide or long .

Depth cues are a set of perceptual principles that determine how we understand our world. In computer screen simulations, some depth cues are not possible with current technology, and therefore the discussion will be limited to the ones that are applicable.

Overlap or occlusion is one of the most important depth cues. The term occlusion refers to the fact that objects near to us block or occlude objects further away. An object that occludes another almost always appears closer (Figure 17).

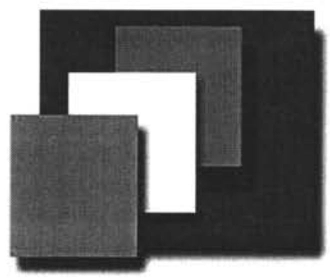


Figure 17. Objects that overlap or occlude other appear closer

Cast shadows and shape-from-shading cast shadows can be used to enhance the apparent distance between overlapping objects. Relatively subtle shading effects can give a 3-D appearance to buttons and widgets, and this is widely used to enhance the perception that certain objects can be grasped and manipulated. This kind of shading of widgets is another instance of a 3D depth cue being used in current graphic user interfaces.

Figure 18. Shading effects provide information about 3d shape of surfaces

Perspective covers a set of depth cues that all derive from the basic geometry of mapping a 3D scene onto a flat screen with a particular viewpoint. This geometry gives rise to three related depth cues (Figure 19).

- Linear perspective refers to the projections of parallel lines converging on the picture plane.
- Texture gradients, refers to the reduction in size and increase in density of texture elements with distance.
- Size gradients refers to the way more distant objects are represented as smaller on the picture plane.

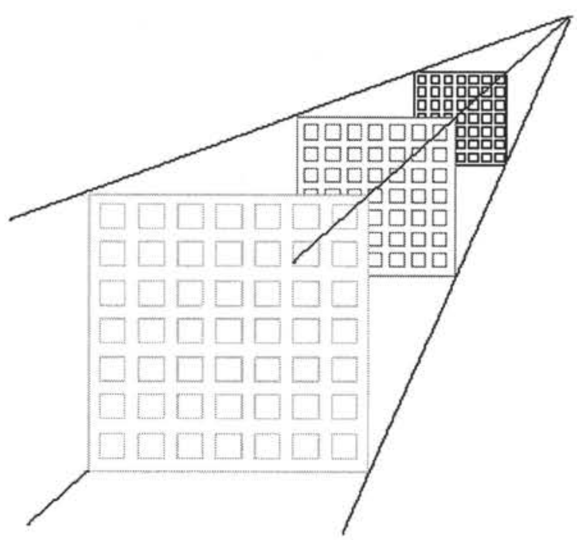


Figure 19. Perspective, size, and texture gradients.

Structure from motion cues state that it is easier to understand a moving structure than a static one. That is the reason why rotation is a standard feature in 3D modeling packages.

Stereoscopic cue is the ability of the human brain to use images from both eyes to determine distances. Stereoscopic cue simulation requires high computing power and is not as critical as the previous cues. (Ware).

4. Site Maps

A fundamental usability principle is to visualize the structure of the information space to help users understand where they can go. Site maps are a common approach to facilitating navigation on the web, however they are often not very successful at conveying the multiple levels of the site's structure (Nielsen, *Site Map Usability*)

In today's web a site maps is usually an alphabetically organized list of contents that very often do not include all the contents of the site, and when it does, it becomes excessively long and losses its main benefit, which is to give an overview of the site (Figure 20).
Site maps have evolved along with the development of the web, from very simple schematics to sophisticated interactive graphic interfaces (Figure 21, 22). This evolution however is still underway and the value of site maps as navigation aids is still a matter of study.

Figure 20. Site map 1

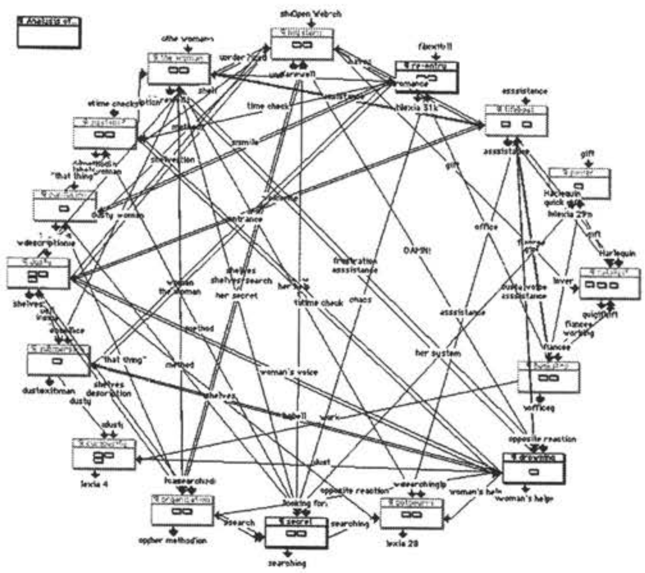


Figure 21. Site map 2

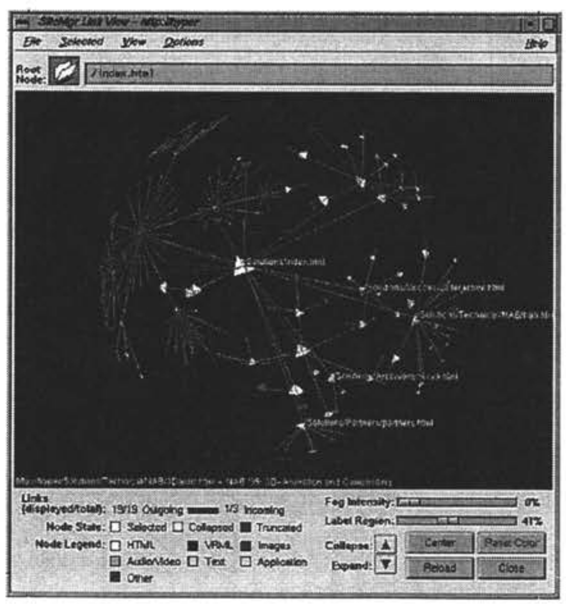


Figure 22. Site map 3

CHAPTER 3

METHODOLOGY

This chapter is divided in three parts. The first part presents a series of design concepts and guidelines extracted from the literature review. The second part describes the process used to select a site for the prototype; and the final part is an analysis of the selected site based on the literature review.

A. Guidelines

The goal of this study is to develop a three-dimensional site-map prototype to increase navigation performance. The literature review provides a set of variables and principles from both navigation maps and web navigation.

1. Wayfinding research has found that providing a visual representation of the underline structure of a setting increases navigation performance.
2. 3D maps are better than 2D maps at presenting complex environments.
3. Maps are orientation signs that must give users an overview of the environment and information to work out a specific route to a destination.
4. The visual elements of a map represent the differences between the features of the environment.
5. Map designers manipulate visual elements, point, line, area, typography, and their attributes, texture, color, orientation, and shape, to represent features of the environment and to facilitate discrimination among them.
6. Research has found that human vision has certain limitation discriminating features in maps.

- In order to discriminate patterns, they must be coarser than 40 lines or dots per inch.

- Point symbol size differences are easier to discriminate when they are between 34%-23%. Abstract symbols are easy to locate within a complex display.
- Type discrimination is consistent when type sizes differ by more than 2 point size in height of capital letter. Attributes such as type size and boldness combination is easier to discriminate than type size and case combination.
- Certain foreground/background color combinations are better to produce the necessary contrast to facilitate legibility of type (Figure 4).

7. Ideally all information should be placed within three hierarchical levels from the initial homepage.
8. Navigation systems should be appropriate for the site purposes and the user goals.
9. A well balanced visually structured page helps users make predictions as to where important information may be located, which is fundamental to the success of a navigation support system.
10. The most commonly used fonts tend to be equally legible at the 10-, 12-, and 14-point size (Figure 16)
11. The use of images and words combined together allow users to rely on recognition, not recall, to understand those meanings.
12. As in the physical world, 3D representations are more efficient at presenting complex structures of information. 3D map are easier to grasp by our intuitive understanding of space
13. 3D elements used in interfaces are easier to identify and remember.

14. By effectively using depth cues, 3D representations are able to accommodate more information than a 2D representation

B. Site selection

This study claims that a 3D web-site map would increase navigation performance. This implies that any website may benefit from the application of this concept and suggests that the best method for choosing the site in support of the thesis would be random. However, some limitations may arise. For that reason there will be some prerequisites for the chosen site.

1. The information necessary to develop a site map may not be available from certain sites. Therefore the first prerequisite is that the chosen site should already have an accessible site map or site index.
2. It is generally found that people make fewer mistakes if the hierarchical structure of the site is broader rather than deeper. In fact, research has generally found that ideally all information should be placed within three hierarchical levels from the initial homepage of the site. However, for sites that must have deeper structures, it has been found that users browsing for specific information find it faster when the hierarchy is broader at the top level than at the lowest level. Hence, the second prerequisite is that the chosen site should not be more that 4 depth levels.
3. Finally, sites that require constant updates, i.e. news sites, directories, etc., are poorly suitable for site-map navigation because constantly updating a map becomes inefficient and costly.

Despite these limitations, the selection process may still be random. A three-step process will be used to select the site. First, a choice of categories will be made among the common categories and subcategories in three of the most popular search engines. Google, yahoo, and AOL. Second, the selected subcategory will generate an alphabetical index or other form of listing from which a subgroup will be chosen. Finally, ten randomly chosen sites from each search engine will be grouped and one site will be randomly chosen from this group. If the chosen site does not meet the prerequisites the process will be repeated.

The three search engines share eight common categories (Table1), and from those, the Recreation and Sports category was chosen. Each search engine has a set of subcategories under Recreation and Sports. The shared subcategories are as follows: Autos, Aviation, Games, Sports, Travel, Outdoors, and Pets. Travel was selected from this group. Again each search engine has subcategories under this title. The shared ones are as follows: Destinations, Lodging, Tour operators, Transportation, Travel agents and Travelogues; form this group Tour operators was selected.

Yahoo has an alphabetical index from which a letter was randomly chosen and a set of ten sites were selected for the final step. AOL and Google share the same subcategories Africa, Asia, Backpacking, Caribbean, Central America, Cycling, Europe, Gay, Lesbian, and Bisexual, North America, Oceania, and South America. From AOL, the Backpacking subcategory was chosen, and from Google the North America subcategory was chosen. From these groups a set of ten sites each were chosen for the final step (Table 2).

Table 1. Common categories in three search engines

Yahoo	Google	AOL
Business & Economy B2B, Finance, Shopping, Jobs...	**Business** Industries, Finance, Jobs,...	**Business** Investing, Real Estate, Small Busin
Computers & Internet Internet, WWW, Software, Games.	**Computers** Hardware, Internet, Software,...	**Computers & Internet** Graphics, Hardware, Software...
Health Diseases, Drugs, Fitness...	**Health** Alternative, Fitness, Medicine,...	**Health** Fitness, Illnesses, Nutrition...
Reference Phone Numbers, Dictionaries,	**Reference** Education, Libraries, Maps,...	**Reference** Dictionaries, Colleges, Maps...
Recreation & Sports Sports, Travel, Autos, Outdoors...	**Sports & Recreation** Basketball, Football, Soccer	**Recreation** Humor, Pets, Outdoors...
Regional Countries, Regions, US States...	**Regional** Asia, Europe, North America,...	**Regional** US, Canada, UK, Europe...
Science Animals, Astronomy, Engineering..	**Science** Biology, Psychology, Physics,...	**Science & Technology** Biology, Environment, Astronomy...
Society & Culture People, Environment, Religion...	**Society** Issues, People, Religion,...	**Society & Culture** Religion, Relationships, Genealogy

Table 2. Final web sites group

Yahoo	AOL	Google
http://www.naturetoursyukon.com/	http://www.theant.com	http://www.acebasintours.com/
http://www.nevisexpress.com/	http://www.dolomitepeak.com	http://toursofcharleston.com/
http://www.scubadive.co.nz/	http://www.straytravel.com	http://toursbybike.com/
http://www.nomadstours.com/	http://www.moosenetwork.com	http://www.ghostsofcarolina.com
http://www.soonet.ca/sailing/	http://www.waywardbus.com.au	http://www.pcgtours.com
http://www.algonquincanada.com/	http://www.backpackerbus.com	http://www.gullahngeechietours.net/
http://www.northwaters.com/	http://www.kiwiexperience.com	http://www.high-country-adventures.bigstep.com/
http://www.nortetrekking.com/	http://www.beetroot.org	http://www.southernbattlefieldtours.com/
http://gorptravel.com/index.html	http://www.thecelticconnection.co.uk	http://pacificbirdtours.com/
http://www.nonnitravel.is/	http://www.kumuka.com	http://www.deleontours.com/

From this group of 30 sites, one was randomly selected.

http://www.nomadstours.com/

C. Site Analysis

The site map should be consistent with the visual language of the rest of the site; therefore, the chosen site is analyzed in terms of information structure, navigation, and visual elements.

http://www.nomadstours.com/ is the web site of Nomads Tours and expeditions, a Mongolian inbound tour operator company whose target audience are outbound travel agencies in Europe, North America and Australia, and individual travelers as well.

1. Cognitive aspects

According to the literature review, there are four major reasons why people make navigational errors in a web site, disorientation, disgression, art museum problem, and the structure itself. These aspects are discussed in relation to **http://www.nomadstours.com/.**

Users may become disoriented or incur in the disgression problem because of the similar appearance of many of the documents. In addition, there are some documents, which are accessible from link descriptions that are not consistent through the whole site. The art museum problem is another factor that may occur in the site. Some pages in the first level have up to 14 different links. According to the characteristics of good web-navigation design discussed in the literature review, the cognitive demands of a page may increase considerably when the number of items to remember exceeds seven.

The interaction elements do not always provide enough information to differentiate the various types of documents available, which makes it hard to grasp the site's organization

http://www.nomadstours.com/ is a 4 level structure composed by 90 documents, which according to their content can be grouped under 5 main sections. All these sections are accessible directly from the homepage. For the purpose of identification, in this analysis each of the sections will be given a name. The first section contains information targeted to the greater portion of the company's clients, which are travel businesses. This section will be called B2B. A second section present overall and specific information about the different kind of trips provided by the company on a regular basis. This section will be called Trips. A third section deals with information for general public interested in traveling in Mongolia. This section will be called B2C. Another section is the support information, which contains help resources about the site such as a site index, troubleshooting and latest news. This section will be called Help. The last section is a small feature of the site that highlights VIP customers. This section will be called VIP (Figure 23)

The first level of documents can be accessed directly from the home page. It consists of 27 documents, 6 from B2B section, 8 from Trips, 7 from B2C, 5 from Help and the VIP document. The second level consists of 19 documents, which are accessible from the first level pages, 15 of them are from Trips, and 4 from B2C. The third level consists of 39 documents all of them from the trips section accessible from several other documents in first and second levels. The fourth level is a media library of 4 movie clips. Accessible also from several documents in first, second, and third levels.

Figure 23. Site main sections

2. Functional aspects

The literature review provided a set of conditions for good navigation systems. Each of these conditions is discussed here to determine whether http://www.nomadstours.com/ meets them.

a. Easily learned by users

http://www.nomadstours.com relies mostly on typography for navigational purposes. Most of the interaction elements are words of phrases grouped in different sections. This characteristic makes it easy to predict what elements are interactive. A smaller group of interaction elements in the homepage, about seven, are photograph-word combinations. Although interactive elements are easy to identify, the amount of them makes the navigation rather confusing especially for a first time user.

b. Consistent

The appearance, location, and behavior of the interaction elements remain consistent through most of the site.

c. Provide feedback

http://www.nomadstours.com does not provide information about user location within the site consistently. In documents where current location information is provided, it needs to be more visually prominent, if it is to help users differentiate among the other features. In terms of responsive mechanisms such as visited links indication, the site provides them only in the bottom navigation bar. Most of the time this bar is not visible without scrolling down. This makes it difficult for users to know where they have been before. Another deficiency is the site identity, which does not appear in all the pages.

d. Appear in context

There is a lack of contextual information in the site. Most documents display a very similar appearance and organization while content vary. Figure 24 shows sample pages of first, second and third levels where it is clear the lack of contextual information. Some tasks in **http://www.nomadstours.com** require users to go back or search for information in another page. This information must be available exactly where needed without the user having to hunt for it.

e. Offer alternatives

http://www.nomadstours.com provides little alternatives for navigation. Besides the main navigation features, the only alternatives it provides are a bottom navigation bar that contains all the navigation links of the homepage and a site index.

Homepage

First level pages

Second level page

Figure 24. Sample pages

f. Require minimal action and time

The interaction speed does not play a critical role for the purpose of the site, which is to advertise the company services; however, the size and specially the organization of the site, makes exploring the entire site a time consuming task. Clarifying the structure may considerably reduce the interaction time.

g. Visually clear.

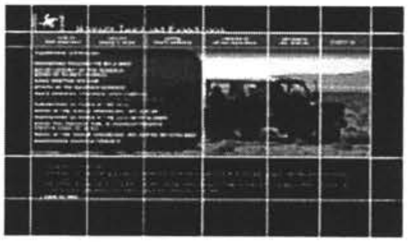
The interaction elements are visually clear in the homepage; however, in some content pages, these elements lack in visual hierarchy.

2. Visual aspects

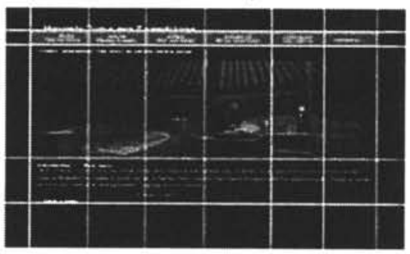
a. Layout

The site uses a six-column grid system, which remains consistent throughout most of the side. The fourth level pages do not follow the grid. The first row displays the site identity. The next row is made out of buttons leading to the B2B category. In the first and second level pages the third row displays the main navigation section along with pictures. In the third level pages the third row presents the content. A final row is a bottom navigation bar (Figure 25).

Homepage



First level page



Second level page

Third level page

Fourth level page

Figure 25. Layout grid

b. Color

The first, second and fourth level pages use a black background, while the third level pages use white background. Most of the pages have an ochre bar, color # 9A6600, right below the page heading. All typography in first and second level pages is white except by the bottom navigation bar, which uses a blue color. In third level pages typography is black.

c. Symbols icons

The site uses an identity symbol in some pages but the symbol is not an interactive element. The homepage has seven interaction elements that are image-word combinations, these images are pictures that do not have a clear intention in terms of communicating a message. There are photographs used in almost every page that are related to the content of the page however these photographs are not interactive.

d. Typography

The site uses two typefaces. Swis 721 is used for most of headings and interaction elements. Trips category links are set in Swis 721 black BT all caps. Subheadings and links to other categories are set in Swis 721 black BT. Introductory text in first and second level pages is set in Swis 721 BT. The contents in third level pages as well as the bottom navigation bar are set in Arial roman.

e. Interactions

The interactions provided by the site are limited to accessing documents by clicking links and to play and stop media library items.

CHAPTER 4

PROTOTYPE DEVELOPMENT

A. Information Hierarchy

Based on the site analysis in the previous chapter, where the site contents were organized in five main categories distributed in four depth levels, the prototype development started by establishing an information hierarchy (Table 3).

The purpose of the site suggests that the contents can be hierarchically classified according to its importance in the following order:

1. Trips
2. Business to Customer
3. Business to Business
4. VIP
5. Help

This ranking was used to make a first attempt to visualize the site through a diagram, which outlines the site organization and the relationships among the different information units and levels (Figure 26).

Table 3. Site Contents

Categories Depth levels	TRIPS	B2C	B2B	VIP	HELP
1st level	Expeditions & Adventure Travel With Style Cultural Yet Comfortable Horseback Expeditions & Camel Treks Trekking & Mountaineering Special Interest Stop-overs & Extensions Budget Travels	Company Info index Country Info index Cultural Info index FAQ Interesting Mongolian Links Virtual Tours Clients' Experiences index	Info For Tour Operators Info For Filming & Media Getting There & Away Calendar of All Departures References Contact us	Julia Roberts	Online Booking Form Troubleshooting About the site Sitemap Sars Update
2nd level	Pioneering Through The Wild West Secret History Of The Mongols Spirits Of The Reindeer Herders Shape Shades & Colors Of Gobi (Camels) Riding The Nomadic Trail In Western Mongolia Riding In The Cradle Of Nomadic Civilization The Five Kings Of Altai Mongolian Classic Tour With Naadam The Great Lakes Of Mongolia Mongolian Classic Tour Lakes of Mongolia With Naadam The Beauties Of The Gobi Edge of Eternity Trekking in the Footsteps of the Great Khan Mountain Biking Birdwatching	Company Info Country Info Cultural Info Clients' Experiences			
3rd level	Sound Of Silence (Camels) Eagle Hunting Festival Fascinating Cultures Of The Altai Fascinating Cultures Of The Altai With Naadam Riding The Nomadic Trail In Zavkhan Province Riding In The Cradle Of Nomadic Civilization Discovering Zavkhan Province Highlights Of Mongolia In Search Of The Secret History Of The Mongols Khenty Wilderness Ride (Camels) Fishing in the Darkhad Valley Terelj (3 days) Khuvsgul (5 days) Karakorum (3 days) Karakorum & waterfall (5 days) South Gobi (4 days) Khentii Outdoors Gobi & Singing Sand Dunes(5days) Khustai (4 days) Bogd National Park(4days) Karakorum & Hotsprings(5days) Package For Self Arrenged Travel Special Offers Pioneering Through The Wild West Secret History Of The Mongols Spirits Of The Reindeer Herders Shape Shades & Colors Of Gobi (Camels) Riding The Nomadic Trail In Western Mongolia Riding In The Cradle Of Nomadic Civilization The Five Kings Of Altai Mongolian Classic Tour With Naadam The Great Lakes Of Mongolia Lakes of Mongolia With Naadam Edge of Eternity Trekking in the Footsteps of the Great Khan				
4th level	Tigress clip Lonely Planet 1ARD Lost				

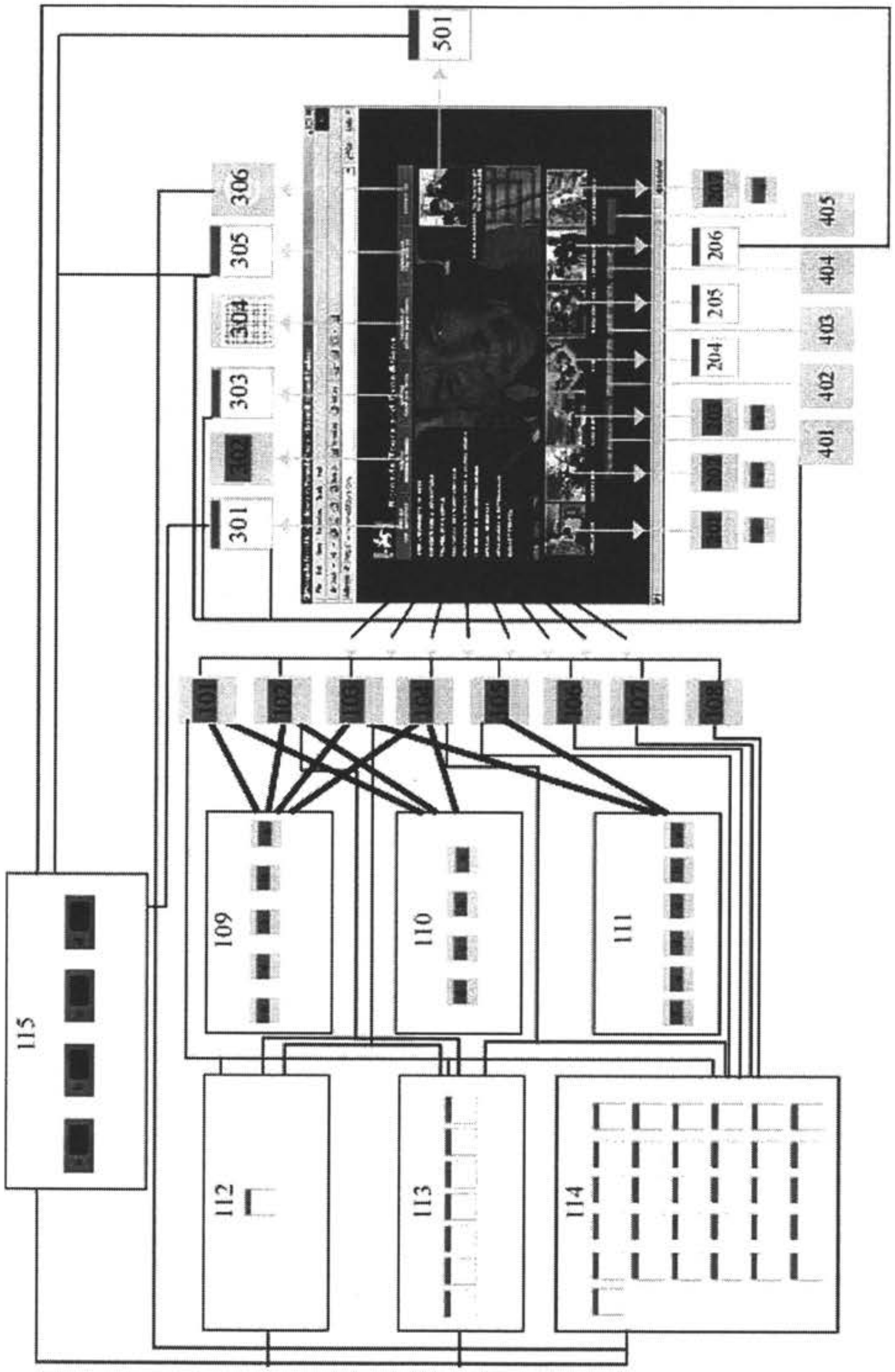


Figure 26. Visualization diagram

This visualization diagram allows seeing the complexity of the structure, and the relationships to be portrayed in the site map prototype.

B. Projection

A wayfinding map depicts and symbolizes selected characteristics of the environment, using a set of visual variables arranged according to an organizing principle called projection, which refers to the users relative viewing position. Likewise, in a web site map these same variables, point, line, area, typography, and projection can be used to represent information units and relationships between those units and the environment. Their attributes, texture, color, orientation, and shape can also be manipulated to develop a visual language to facilitate discrimination among environmental features.

Given the purposes of a site map, which are to give an overview of the site's structure and to facilitate locating information units, the projection plays and important role. It allows users to develop a mental representation of the site in a single glance, therefore facilitating navigation.

Several types of projections commonly used in wayfinding maps were discussed in the literature review; plan view, axonometric, perspective, schematic and fantasy. Each projection type has characteristics that make them suitable to emphasize certain environmental features. In order to determine the most appropriate projection, several models of the site were created to test each projection type by analyzing their advantages and disadvantages (Appendix). Also an evaluation matrix was used to compare each projection type against the criteria developed in the methodology chapter (Table 4).

1. Plan view.

The plan view uses a set of geometric point symbols to represent different types of information units. Solid color squares represent the five main categories; outlined circles represent first level pages; filled circles represent second and third level pages, and finally hexagons represent fourth level pages. Lines indicate relationships between levels and relationships between specific documents are indicated by color (Figure 27).

This view gives a good idea about the general configuration of the site and the relationships among depth levels. However in order to show relationships between specific information units, some symbols require up to three different colors, which in a small symbol, especially in a low-resolution media such a computer screen become hard to discriminate. Another disadvantage of the plan view is that the location of symbols alone does not provide enough indication as to how they relate to each other. This makes necessary the use of colored areas to indicate how symbols are grouped together.

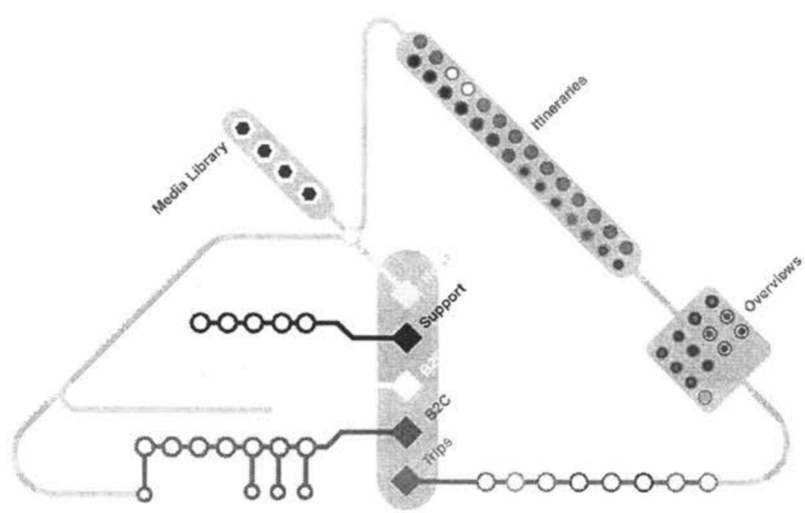


Figure 27. Plan view

2. Axonometric View

This example also uses a set of geometric point symbols to represent different types of information units. However, in contrast to the flat plan view, the symbols are three-dimensional, which provides an additional opportunity to show extra information in the symbol itself. For example by taking the main categories symbols from the plan view and making them three-dimensional, it is possible to indicate that the trips category is hierarchically more important than the other categories (Figure 28).

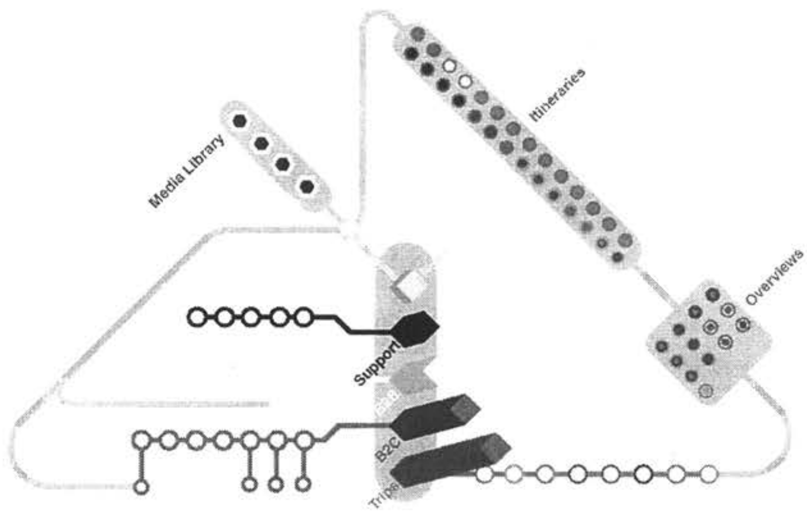


Figure 28. Axonometric 1

Another advantage of the axonometric view is the use of spatial relationships. 3D symbols can be related to each other without a physical connection such as a line. In addition, the introduction of the structure from motion depth cue allows the 3D model to be rotated facilitating the understanding of the structure. A disadvantage of the axonometric view resides in the fact that the advantage point height has to remain unchanged and the rotation should occur relative to that height. (Figure 29). When the advantage point height is modified, the view becomes a perspective.

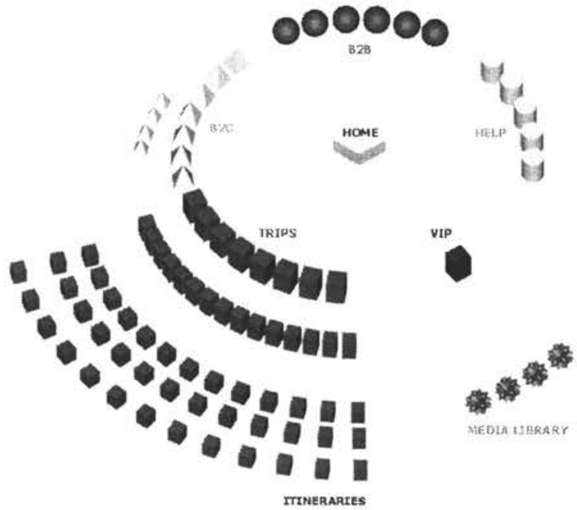


Figure 29. Axonometric 2

3. Perspective view

In contrast to the limitations of perspective views for wayfinding maps described in the literature review, in a computer generated 3D model, perspective views of are superior to plan or axonometric views because the 3D model can be seen from any advantage point without limitations. A perspective view combines the advantages of plan and axonometric view plus it overrides their limitations. A perspective is useful to emphasize any feature within the structure by locating it closer to the user's advantage point. For instance if a user is interested in particular object within the 3D model, the advantage point can be modify in real time according to the user preferences while the structure overview remains available. Figures 30 a,b,c, show the same 3D model seen from three different advantage points.

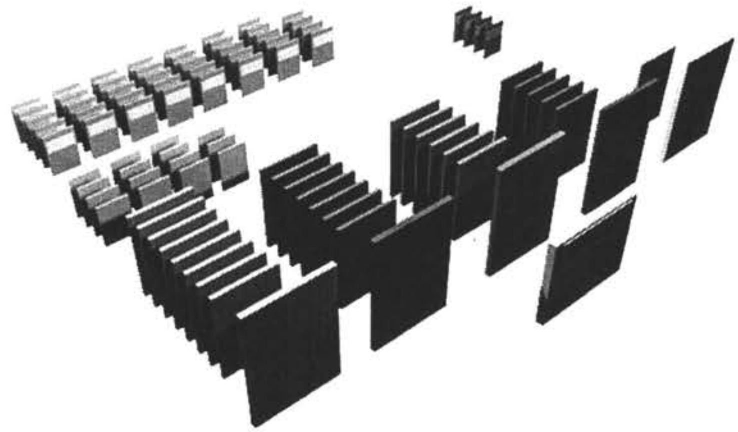


Figure 30. a. Perspective view

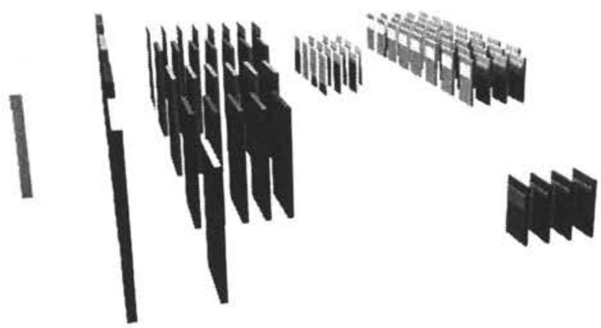


Figure 30. b. Perspective view

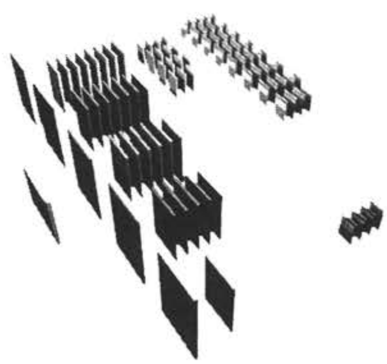


Figure 30. c. Perspective view

4. Schematic and Fantasy Views

In wayfinding maps, these views make use of different means to depict certain existing environmental features. Schematic views, for instance, use geometric shapes and spatial relationships, fantasy views use content related metaphors as in figure 31, which uses an orbital system to represent the structure. In the case of a web site map in which the environment to be represented does not have any given shape or real environmental features that can be schematized, any of the previous views, plan, axonometric or perspective, can be considered a schematic or fantasy view. Figures 31 to 36 show examples of schematic or fantasy views.

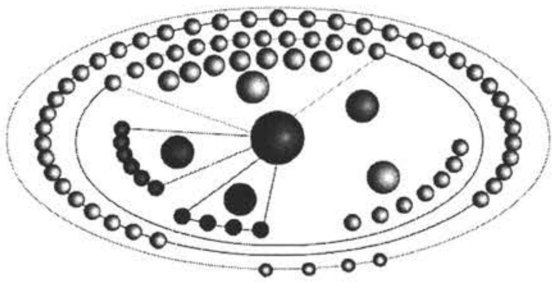


Figure 31. Orbital system

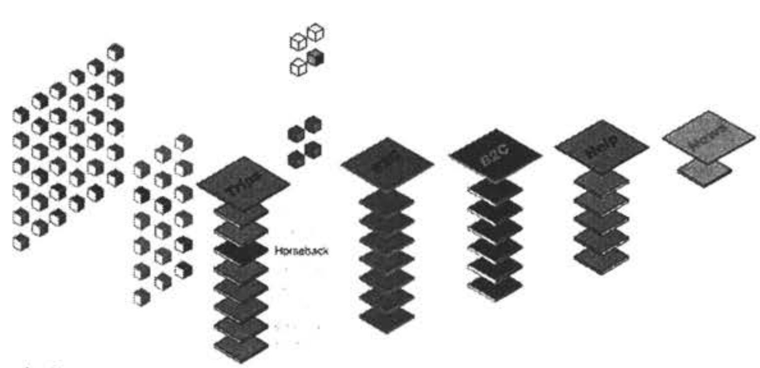


Figure 32. Schematic 1

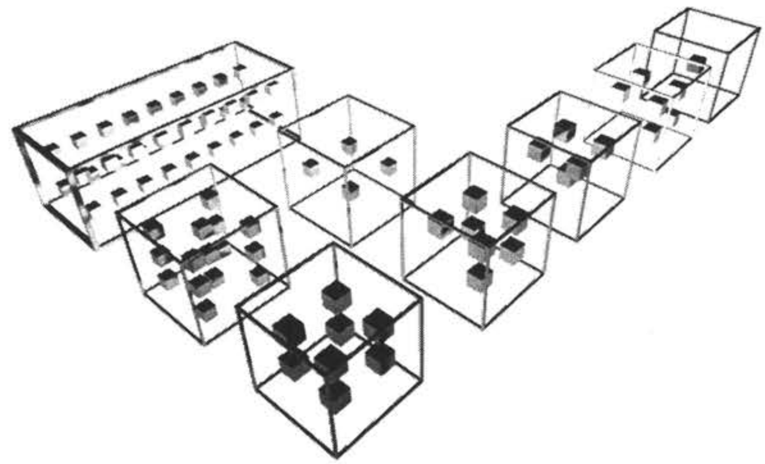


Figure 33. Schematic 2

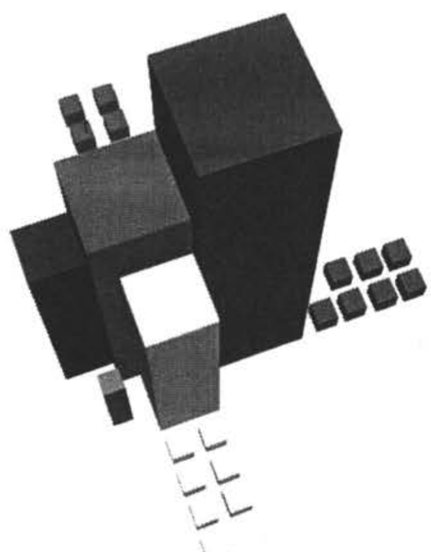


Figure 34. Schematic 3

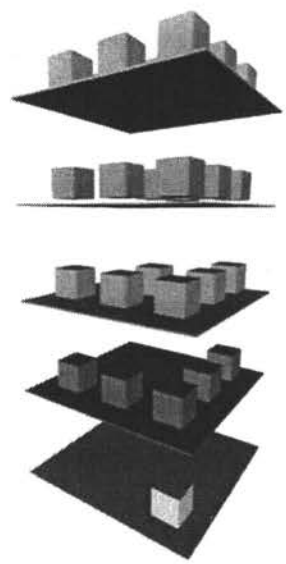


Figure 35. Schematic 4

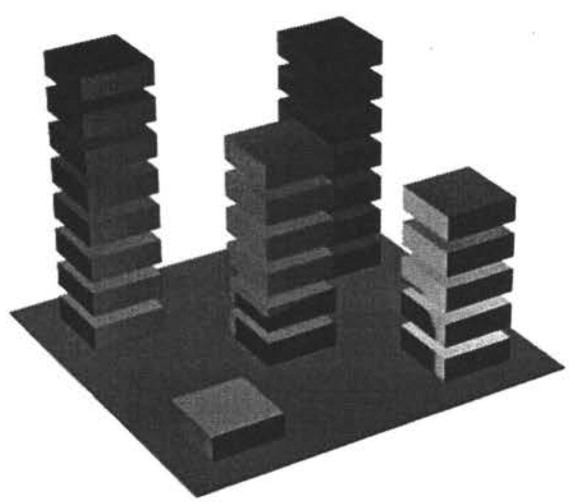


Figure 36. Schematic 5

C. Typography and point symbols

Common to all views is the problem of typography. According to the literature review typography should be placed parallel to the viewing plane. Typography placed at any other angle decreases in legibility therefore is not recommended that typography follow the same rules of a 3D object (Figure 37). Similarly pictorial and associative symbols decrease their ability to communicate when rotated at an angle. In contrast geometric symbols can be recognized even when rotated (Figure 38).

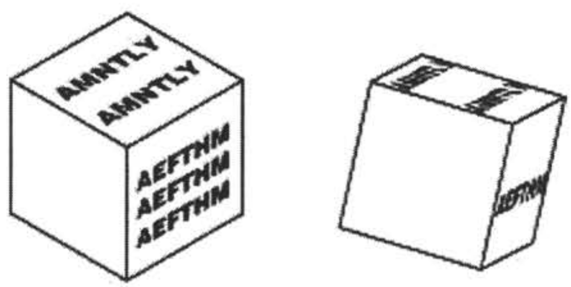


Figure 37. Type in axonometric and perspective views

Figure 38. Symbols in axonometric view

D. Evaluation Matrix

The literature review and methodology chapters provided a set of guidelines and principles for the design of the site-map prototype. The following table, which summarizes these parameters, was used to select the projection type for the development of the final prototype through a self -evaluation process. Each projection type was evaluated using the following 15 parameters: 3D, overview, step by step route, simplicity, scrolling, interaction time, visual structure, features discrimination, 3D point symbols, easy to learn, consistency, feedback, alternatives, context, and symbol word combination. Each parameter was graded using a 1 to 5 scale based on the Likert scaling system. Then the points of each projection points were summed to determine the more appropriate (Table 4).

The analysis of the examples and the results of the evaluation matrix suggest that perspective and schematic views are the most appropriate projections for the site-map prototype. Axonometric and fantasy views ranked close to one another in second and third place and plan view was last.

Table 4. Evaluation Matrix

Projection Type / Design Parameters	PLAN	AXONOMETRIC	PERSPECTIVE	SCHEMATIC	FANTASY
3 D	0	4	5	5	5
Overview	3	4	5	5	5
Step by step Route	2	5	5	5	4
Simplicity	3	5	5	4	4
Scrolling	5	5	5	5	5
Interaction Time	3	4	4	4	4
Visual Structure	3	5	5	5	4
Features Discrimination	2	4	5	5	4
3D point symbols	0	4	5	5	4
Easy to learn	3	4	5	5	4
Consistency	5	5	5	5	5
Feedback	5	5	5	5	5
Alternatives	3	4	5	5	5
Context	5	5	5	5	5
Symbol word combination	5	5	5	5	5
TOTAL	42	69	74	73	68

E. Refinement

Having established the type of projection that better serves the purpose of presenting the site structure, the following step is to determine its visual qualities.

The site analysis again revealed certain visual characteristics that are implemented through the entire site. Color palette, symbols, and typographic treatment and face choice (Table 5). These variables are then applied to the selected projection.

Table 5. Existing visual specifications

Existing visual specification		
Color	**Typography**	**Symbols**
Black	Swis 721 B BT ALL CAPS	Arbitrary
White	Swis 721 B BT	
Ocher color # 9A6600	Swis 721 BT	
Blue Browser default	Arial roman	

1. Color

The site map uses color coding as the strategy to indicate differences between information categories. Five colors taken from the homepage were incorporated to indicate each of the main categories. In addition the lighting effects necessary to display a 3D model produces variation in the colors by virtue of shadow and shine. This effect is partially lost when white or black backgrounds are used (Figures 38, 39). Therefore in order to facilitate the display of the 3D model, the background uses the ocher color. This allows a better display of the model without loosing details.

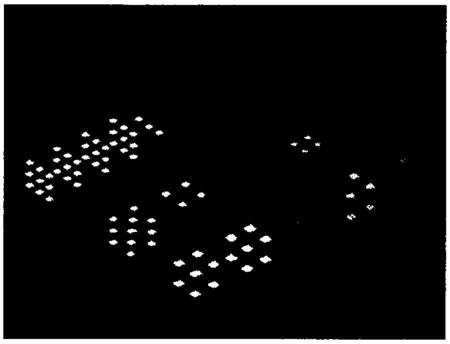


Figure 39. Black background

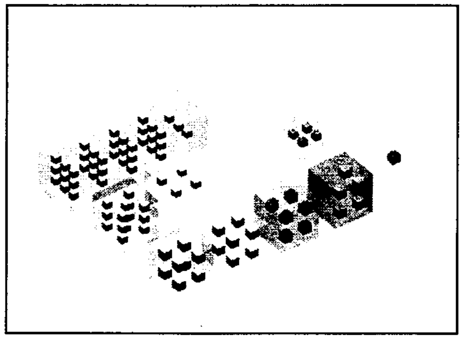


Figure 40. White background

2. Typography

The existing typographic elements used for navigation in nomadstours.com are presented as images, which allow them to be displayed consistently in most computer screens. Following this method, a typographic system was developed to label the site features. Labels indicating Main categories are set in Swis 721 Black BT all caps; first level page labels are set in Swis 721 Black BT upper and lower case; second level page labels are set in Swis 721 BT upper and lower case; third and fourth level page labels are set in Arial roman.

MAIN CATEGORIES	Swis 721 Black BT
First level pages	Swis 721 Black BT
Second level pages	Swis 721 BT
Third level pages	Arial roman
Fourth level Pages	Arial roman

3. Point Symbols

Point Symbols used in the prototype are colored coded cubes whit size differences of 34%. Their location, spatial relationships and color give enough information to allow discrimination of these features.

Figure 41 Point symbols

These variables were applied to the selected projection in figures 42 through 45.

4. Interactions

Interaction plays a critical role in the functionality of a site-map. The prototype integrates standard web interactions such as rollover images with three-dimensional actions such rotation to create the necessary interactivity. This integration is made possible by combining a 3D modeling package, Discreet 3ds max 4.2, and Macromedia Director MX using shockwave technology. Appendix B contains a digital file with samples of the site-map interactivity. The disk is compatible with windows 98 or superior, requires Internet explorer 6.0 and shockwave player.

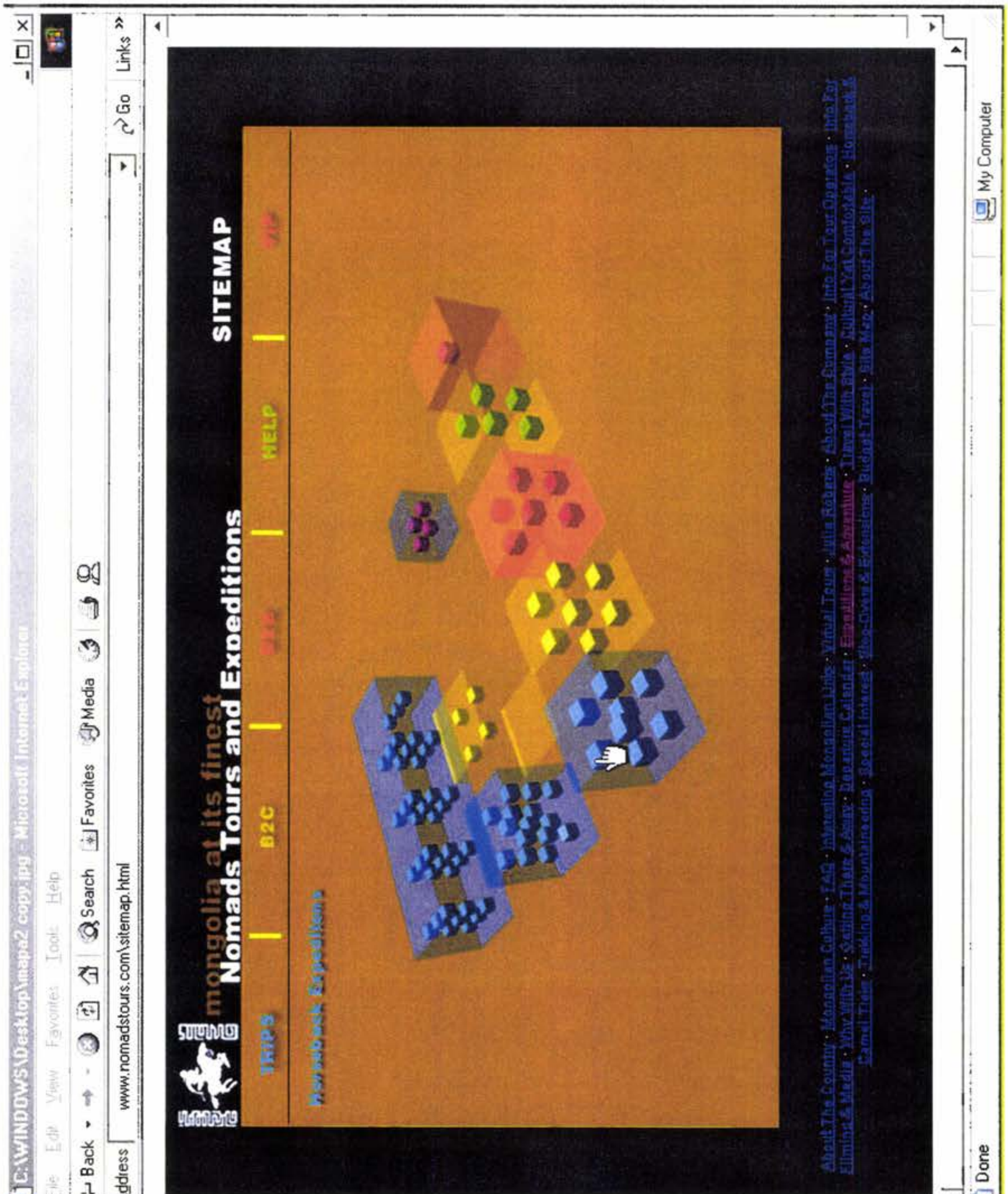


Figure 42 Prototype 1

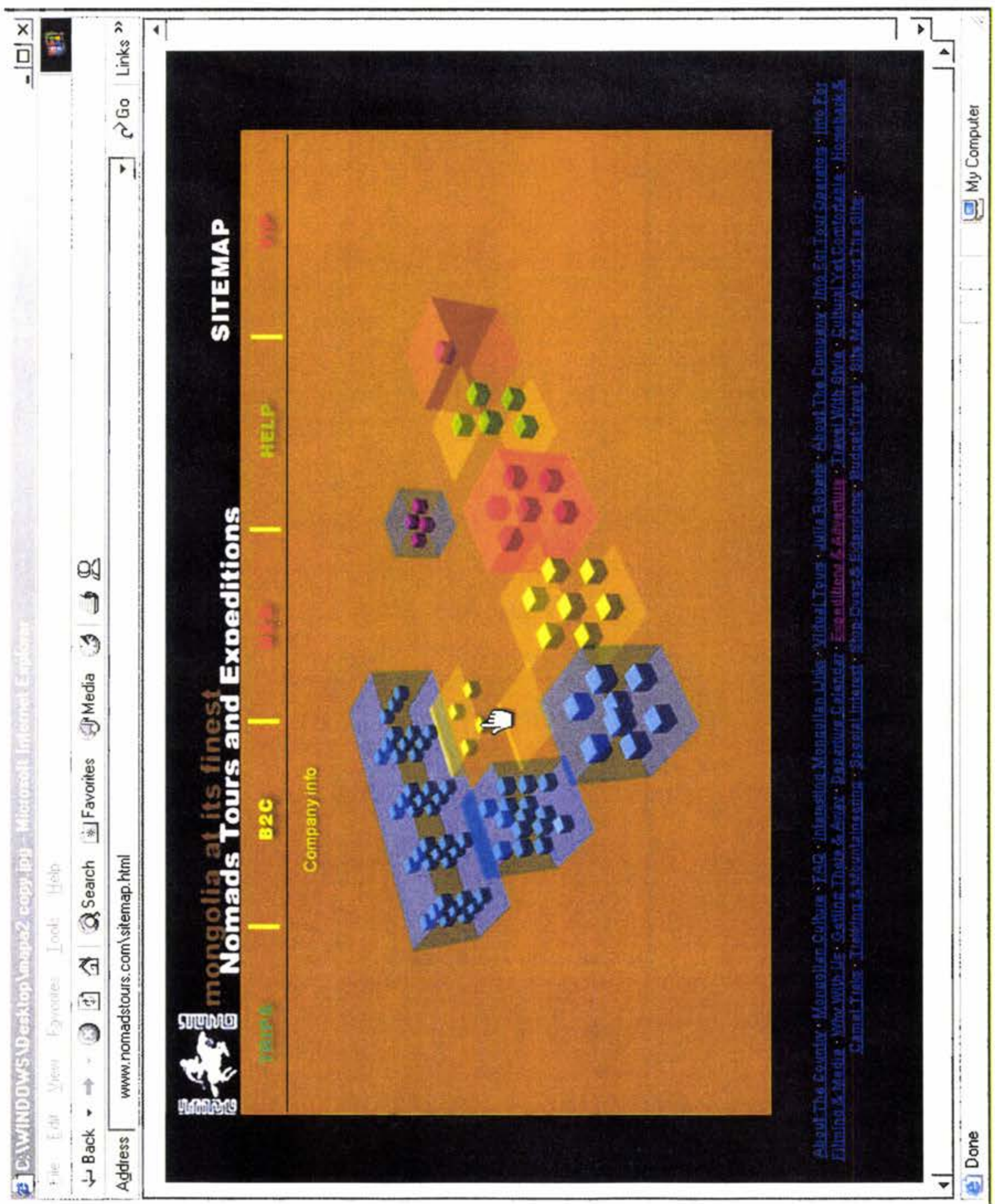


Figure 43. Prototype 2

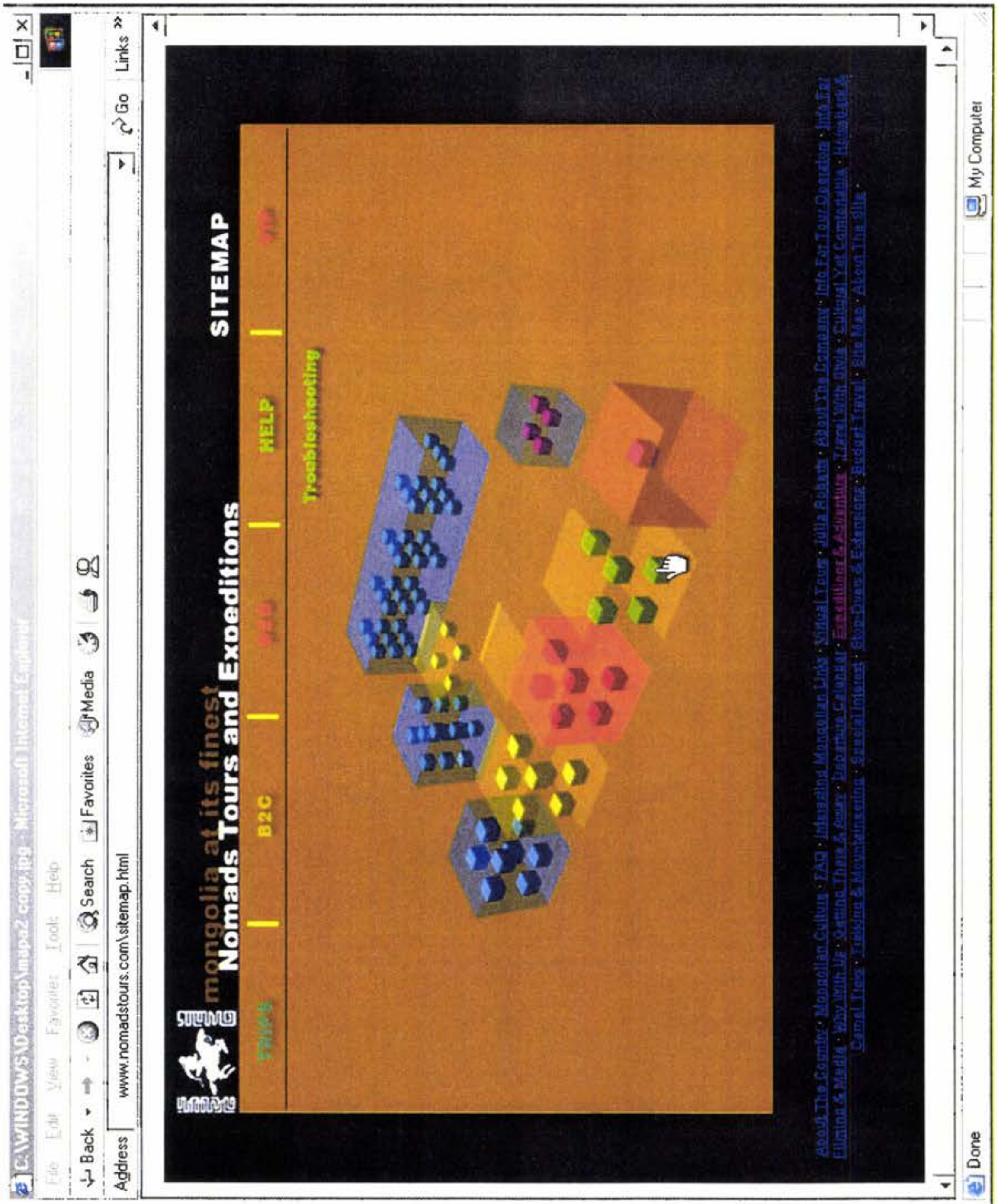


Figure 44. Prototype 3

Figure 45. Prototype 4

CHAPTER 5

CONCLUSIONS

The purpose of this research was to examine the implications of 3D models as navigation devices for web sites. In such attempt, it was found that a three-dimensional map is a real alternative to improving navigation on web sites because it takes advantage of human experience and perception abilities to make users rely on intuition rather than recall to interact with the interface.

The experience of navigating a web site is not very different than navigating a real concrete environment. Both have starting points and destinations arranged according to organizing principles, and when these organizing principles are made known to users, navigation can be facilitated.

Because our common experience in tha three-dimensional world, and our ability to comprehend 3D objects and spatial relationships, 3D models are easier to grasp than other forms of visualization. They have a number of advantages over other forms of visualizations because they retain 3D properties that facilitate comprehension. Such properties, combined with standard graphic user interface concepts and elements, offer a great potential as navigation mechanisms. Computer generated 3D models can be a more intuitive way of presenting complex structures of information to users.

The interdisciplinary approach used for this research facilitated the discovery of an alternative solution to common problems of web navigation. As a first step towards the development of a 3D-site map, this study was focused on the cognitive and visual aspects of it. The methodological approach for the prototype design provides a starting point for further investigation. More research is needed to study the usability of this type of mechanisms through formal user testing and the technical ramifications of implementing such mechanisms.

Site maps should become more aware of users needs and perceptive abilities. By employing alternative ways to design information, the experience of navigating a web-site can be enhanced.

WORKS CITED

Arthur, Paul, and Passini, Romedi. Wayfinding People, Signs and Architecture. McGraw-Hill, Inc. New York :1992.

Bateson, Gregory, Steps to and ecology of mind: Collected essays in anthropology, psychiatry, evolution, and epistemology. University of Chicago Press. 2000.

Bernard, Lida, Riley, Hackler, & Janzen, "The Software Usability Research Laboratory" 2002. (http://psychology.wichita.edu/optimalweb/text.htm) 04/17/02

Boechler, Patricia M. "How Spatial Is Hyperspace? Interacting with Hypertext Documents: Cognitive Processes and Concepts." Cyber Psychology & Behavior 2001 Vol. 4 (1), 23-46.

Darken, Rudolph P., and Barry Peterson. "Spatial Orientation, Wayfinding, and Representation" Handbook of Virtual Environments Design, Implementation, and Applications. Ed. Kay M. Stanney. LEA. New Jersey: 2002. 493-518.

Flemming, Jennifer., Web Navigation: designing the User Experience. O'Reilly & Associates, Inc. 1998

Forsythe, C., Ring, L., Grose, E., Bederson, B., Hollan, J., Perlin, K., & Meyer, J. (1996). Human Factors Research and Development for the Internal Web at Sandia National Laboratories: A Review and Update (conference proceedings).

Institute for color research (www.ccicolor.com/research.html)

Kahn Paul, Lenk Krzysztof, Kaczmarek Piotr., "Applications of isometric projections for visualizing web sites" Information Design Journal. 2001, 10(3), 221-228

Lynch, Patrick J., "Visual Design for the User Interface" Part 1: Design Fundamentals. Journal of Biocommunications. 1994, 21 (1), 22-30. http://www.med.yale.edu/caim/caim/publications_OLD/papers/gui.p1.html 10/9/02

Lynch, Patrick J., and Horton, Sarah., Web Style Guide. Yale University Press, 1999.

MacEachren, Alan How maps work, representation, visualization, and design. The Guilford Press. New York 1995.

Norman, D.A., The psychology of every day things. Basic Books, New York 1988.

Nielsen, Jakob. " My Foreword to Mullet and Sano's Book on Visual Design" 1994. http://www.useit.com/books/mullet_sano_foreword.html

Nielsen, Jakob. " Seductive User Interfaces" 1996. http://useit.mondosearch.com/cgi-bin/MsmGo.exe?grab_id=3955032&EXTRA_ARG=&host_id=2&page_id=283&query=Seductive+user+interface&hiword=SEDUCTIVE+USER+INTERFACE+USERS+INTERFACES+INTERFACING 10/7/02

Nielsen, Jakob. "Site Map Usability" 2002. http://www.useit.com/alertbox/20020106.html 12/4/02

O'Neil Michael, "Theory and research in design of you are here maps" Visual information for everyday use Design and research perspectives. Ed. Zwaga, Boersema and Hoonhout. Taylor and Francis Inc. Philadelphia,1999. 225-238.

Passini, Romedi. Wayfinding in Architecture. Van Nostrand Reinhold, 1984.

Rosenfeld, Louis., Morville, Peter. Information Architecture for the World Web Wide. O'Reilly & Associates, Inc. 1998.

Ware, Colin, "Designing with a 2 ½-D attitude" Information Design Journal. 2001, 10(3), 258-265.

Columbia university axonometric view, http://www.mapposter.com/mpcolumbiafs.html. 01/23/03

Manhattan subway system plan, http://www.jonathanpilling.com/Subway%20map.htm 08/10/02

Perspective view, http://www.canberra.edu.au/welcome. 07/08/02

Controlled airspace map http://www.wff.nasa.gov/images/airspace.jpg 07/08/02

Denver International airport http://www.flydenver.com/maps/inside/terminal.asp 02/28/03

Sky Map http://www.aero.jussieu.fr/~jgoutail/images-soho/carteciel.JPG 05/21/03

Genome Map http://www.life.uiuc.edu/animalbiology/biohistory/genome.html 05/21/03

Chemical Compound http://nslsweb.nsls.bnl.gov/nsls/sci&tech/science/2002/images/09-Sussman-figure2.jpg 05/21/03

Columbia University Network . http://www.columbia.edu/acis/maps/network.gif 05/21/03

BIBLIOGRAPHY

Bowman, D., Koller, D., & Hodges, L "Travel in immersive virtual environments: An evaluation of viewpoint motion control techniques." Proceedings of the Virtual Reality Annual International Symposium. Albuquerque, NM: IEEE Computer Society Press. 1997. 45-52

Carliner, Saul., "Inconspicuous Consumption: Lessons for Web Design from Mall and Retail Design" 2002, http://www.boxesandarrows.com/archives/print/002974.php 10/11/02

Carliner, Saul., "Big boxes and Shoppertainment : More Lessons for Web Design from Mall and Retail Design" 2002, http://www.boxesandarrows.com/archives/print/002981.php 10/11/02

Carliner, Saul., "Designing for Real People: Additional Lessons for Web Design from Mall and Retail Design" 2002, http://www.boxesandarrows.com/archives/print/002987.php 10/11/02

Chen, J. L., Stanney K. M. 1999

Cockburn, Andy & McKenzie, Bruce., "What do web users do? An empirical analysis of web use" International Journal of Human-Computer Studies. 2001, Vol. 54, 903-922.

Hedberg, John G., Harper, Barry, Brown Christine., "Reducing cognitive load in multimedia navigation" Australian Journal of Educational Technology. 1993, 9(2), 157-181

Kim, H., & Hirtle, S.C. Spatial Metaphors and Disorientation in Hypertext Browsing. Behavioral and information Technology, 1995. 14 239-250.

Laurel, Brenda, Ed. The Art of Human Computer Interface Design. Addison-Wesley Publishing Co., 1990.

Lynch, Kevin., The Image of the City. The Technology Press & Harvard University Press, 1960.

"The need to recognize and pattern our surroundings is so crucial and has such long roots in the past, that this image has wide practical and emotional importance to the individual. Obviously a clear image enables one to move about easily and quickly...But an ordered environment can do more than this; it may serve as broad frame of reference, an organizer of activity or belief or knowledge...Like any good framework , such a structure gives the individual a possibility of choice an a starting point for the acquisition of further information." Lynch, Kevin., The Image of the City. The Technology Press & Harvard University Press, 1960. p 4

Lynch, Patrick J., "Visual Design for the User Interface" Part 2: Graphics in the Interface. Journal of Biocommunications. 1994, 21 (2), 6-15. http://www.med.yale.edu/caim/caim/publications_OLD/papers/gui.p2.html 10/9/02

Murphy, James B. What Makes People Click? An Analysis of Web Page Navigation UMI Dissertation Services 1998

Nielsen, Jakob., Designing Web Usability. New Riders Publishing, 2000.

Nielsen, Jakob. & Tahir, Marie., Homepage Usability. New Riders Publishing, 2002.

Nielsen, Jakob. " My Foreword to Mullet and Sano's Book on Visual Design" 1994. http://www.useit.com/books/mullet_sano_foreword.html 8/9/02

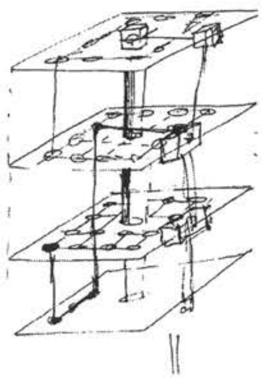
Rosenfeld, Louis., Morville, Peter. Information Architecture for the World Web Wide. O'Reilly & Associates, Inc. 1998

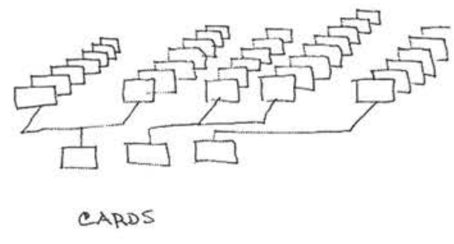
Sano, Darrel., Designing Large-scale web sites: a visual design methodology. John Wiley & Sons, Inc. 1996

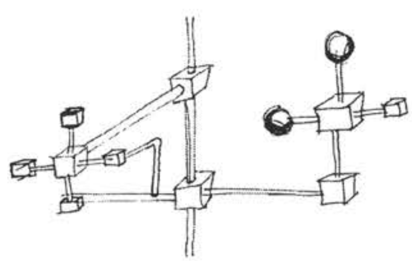
Shedroff, Nathan., "Information Interaction Design: A Unified Field Theory of Design" 1994. http://www.nathan.com/thoughts/unified/ 8/9/02

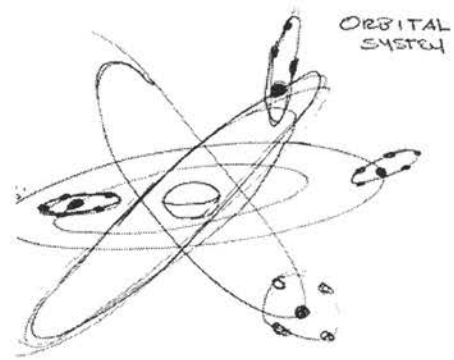
Stanney, Kay M., Ed. Handbook of Virtual Environments. Design, Implementation and Application. Lawrence Erlbaum Associates Publishers, 2002

APPENDIX A - VISUAL PROTOTYPE DEVELOPMENT

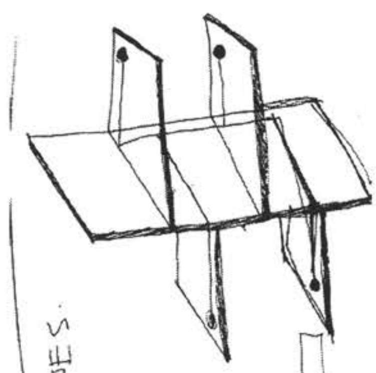


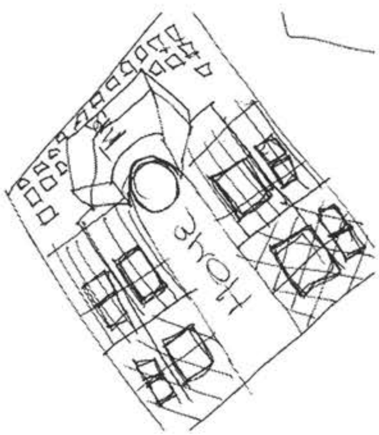

CARDS

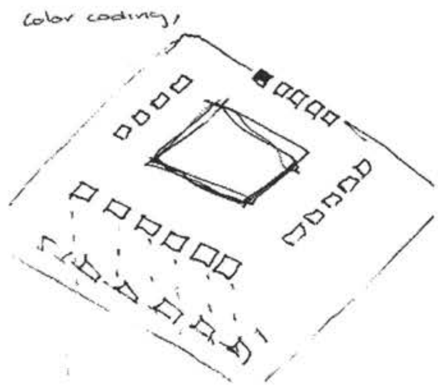


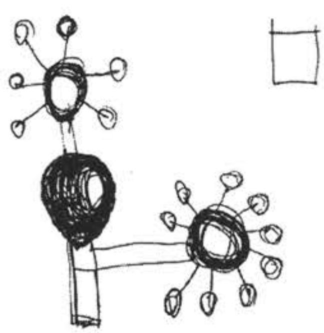

ORBITAL
SYSTEM

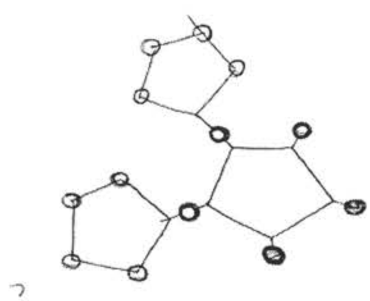

AIRPORT COURI

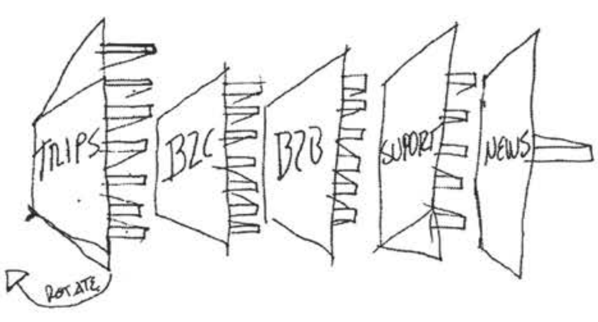


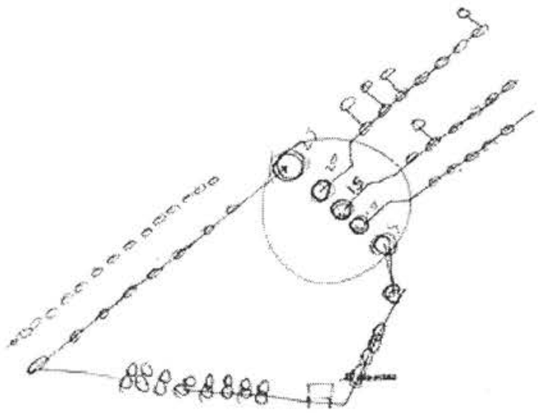

HOME

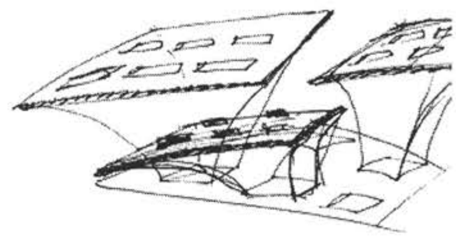

Color coding,

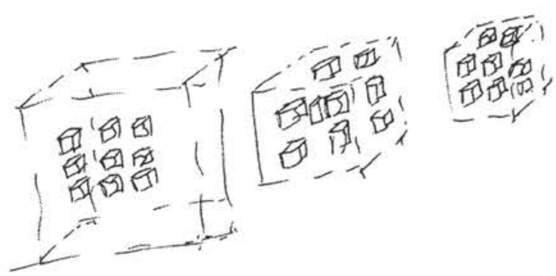


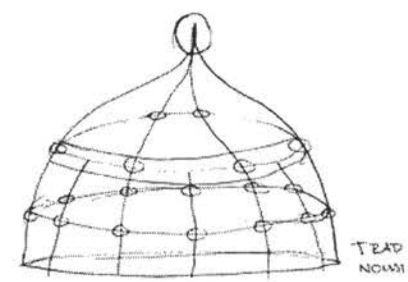


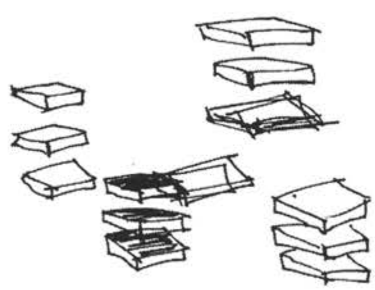

TRIPS
B2C
B2B
SUPORT
NEWS
ROTATE

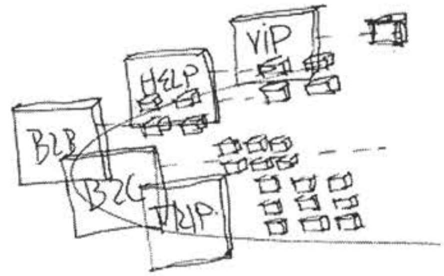


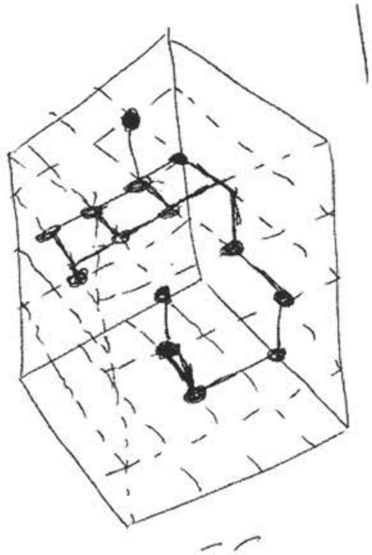


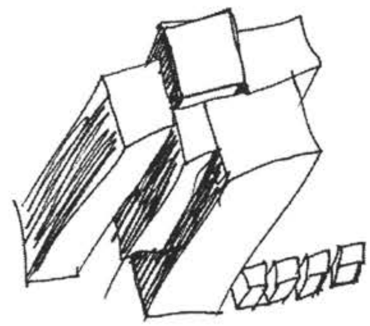


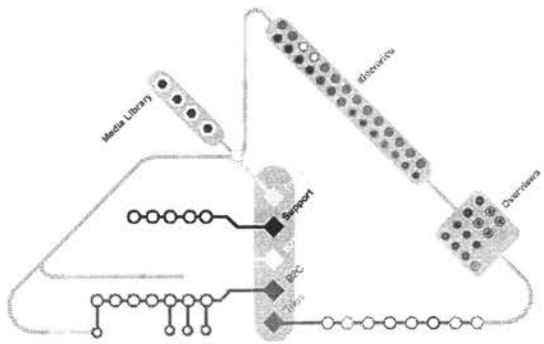

TRAD

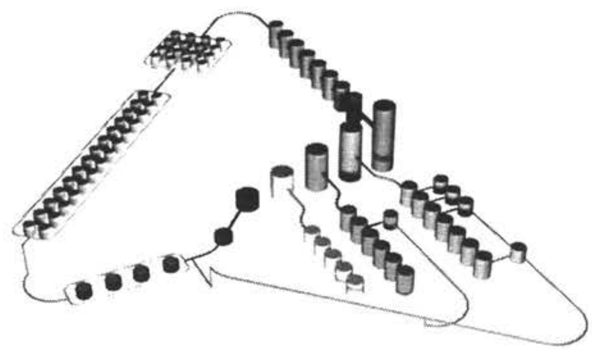


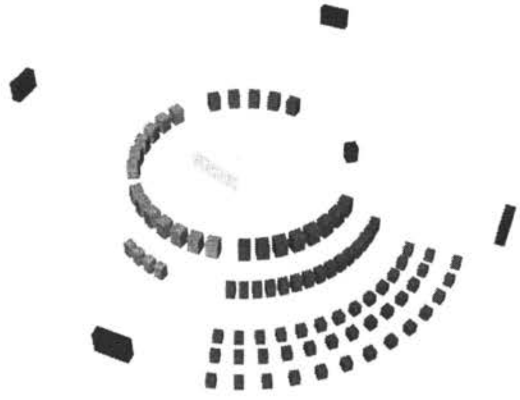

ViP
HELP
B2B
B2C

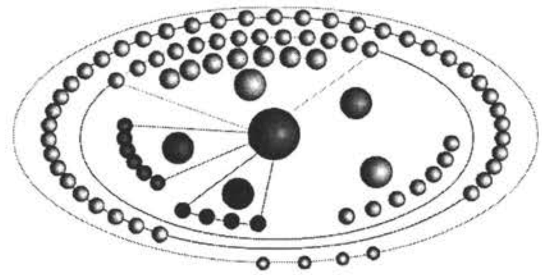


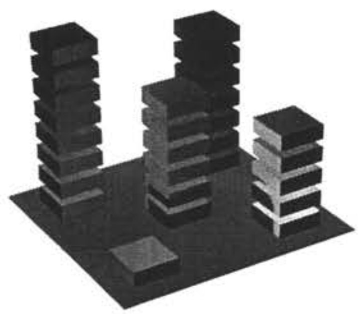


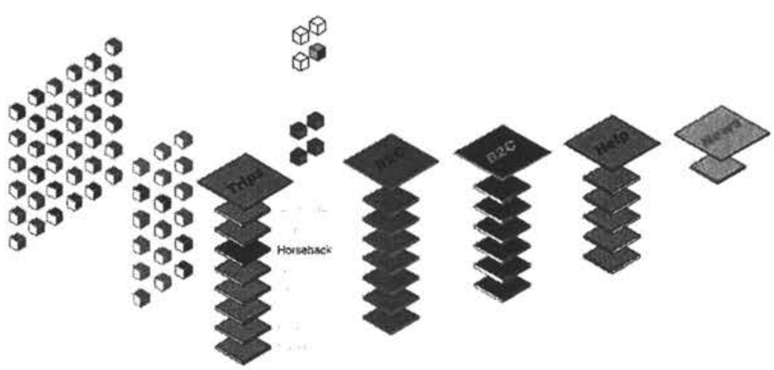

Media Library
Support
Overviews

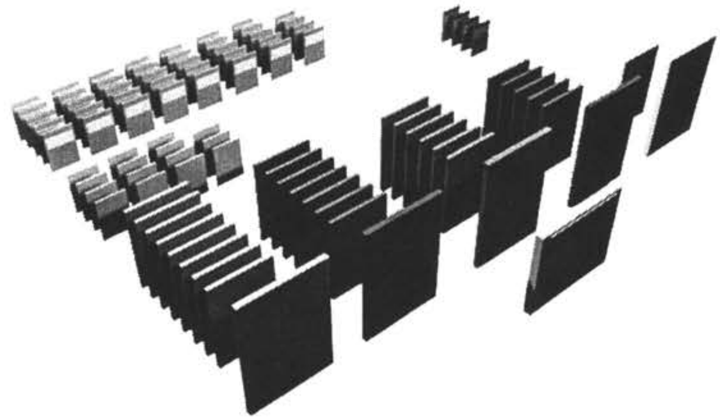


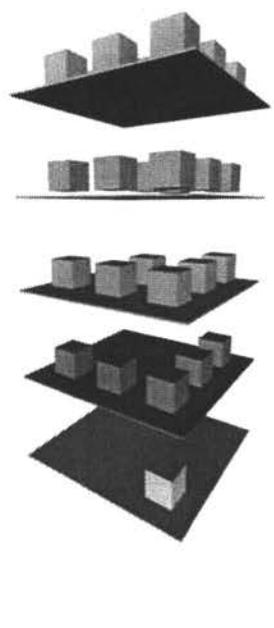







Trips
B2C
Help
Horseback






C:\WINDOWS\Desktop\mapa2 copy.jpg - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address www.nomadstours.com\sitemap.html
Go Links
Nomads Tours and Expeditions
SITEMAP
TRIPS
B2C
HELP
Troubleshooting
Done
My Computer


C:\WINDOWS\Desktop\mapa2 copy.jpg - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address www.nomadstours.com\sitemap.html
Go Links
Nomads Tours and Expeditions
TRIPS
B2C
HELP
SITEMAP
Horseback Expeditons
Done
My Computer

APPENDIX B – ACCOMPANYING DISK AND TECHNICAL REQUIREMENTS

System requirements for accompanying disk: IBM PC or 100% compatibles; Windows 98 or higher; requires Internet explorer 6.0 and shockwave player.

The accompanying disk contains digital files with samples of the site-map interactivity.

ACKNOWLEDGMENTS

I want to thank Sunghyung Ryoo Kang, my major professor for her valuable advice and commitment to the success of this study. Likewise my gratitude goes to professors Alan Mickelson in the department of Art and Design and Mickesch Muecke in the department of Architecture for their support and review of this thesis.

I would also like to thank the entire faculty and staff in the department of Art and Design at Iowa State University.